BELL & HOWELL SCHOOLS

MANUAL 9575

OSCILLOSCOPE THEORY AND OPERATION

500-46

MATERIALS

1 - Type 7400 IC

2 - NPN Transistors

1 - PNP Transistor

2 - Silicon Diodes

1 - 10Ω, 1W, 20% Resistor

1 - 20Ω, 1/2W, 5% Resistor

1 - 100Ω, 1/2W, 20% Resistor

1 - 390Ω, 1/2W, 10% Resistor

1 - 470Ω, 1/2W, 20% Resistor

1 - 560Ω, 1/2W, 10% Resistor

1 - 1 kΩ, 1/2W, 10% Resistor

1 - 1.8 kΩ, 1/2W, 10% Resistor

2 - 2.2 kΩ, 1/2W, 10% Resistors

1 - 3.9 kΩ, 1/2W, 10% Resistor

1 - 4.7 kΩ, 1/2W, 20% Resistor

2 - 10 kΩ, 1/2W, 20% Resistors

1 - 47 kΩ, 1/2W, 20% Resistor

1 - 100 kΩ, 1/2W, 20% Resistor

1 - 5 kΩ Potentiometer

1 - 1 MΩ Potentiometer

1 - 1000 µF, 50V DC Electrolytic Capacitor

2 - 10 µF, 50V DC Electrolytic Capacitors

1 - .1 µF, 100V DC Disc Capacitor

1 - .01 µF, 100V DC Disc Capacitor

3 - Transistor Sockets with Leads

1 - 14 pin DIP IC Socket

4 - Trimounts with Brackets

17 - Modular Connectors

Hookup Wire

PROJECT I

VERTICAL AMPLIFIER CIRCUIT BOARD

PARTS NEEDED

IOD-4540 Vertical Amplifier Circuit Board Assembly Parts.

- 2 - Silicon Diodes
- 1 - 1000 µF, 500V DC Electrolytic Capacitor
- 13 - Modular Connectors
- 1 - 1 kΩ, 1/2W, 20% Resistor
- 2 - 2.2 kΩ, 1/2W, 10% Resistors
- 1 - 5 kΩ Pot
- No. 22 Hookup Wire
- 1 - MegΩ Pot

DISCUSSION

Most of the circuitry in your IOD-4540 Oscilloscope is mounted on four printed circuit boards. After each board has been assembled, you will analyze circuit operation, make voltage and resistance measurements, and perform experiments with the circuit boards.

The oscilloscope circuits use dc operating voltages that the design console can provide. The sinewave generator will also be used as a test signal source for some projects in this manual. The PARTS NEEDED lists do not include tools, test equipment, and solder. It is assumed that you have these items readily available.

To use the oscilloscope circuit boards on the design console, it will be necessary to temporarily solder several wires to the boards. These wires will be inserted into lettered holes from the component side of the boards and lightly soldered to the foil. When soldering these temporary wires, it is important that you do not use any more solder than absolutely necessary. Since the temporary leads will be removed after the tests have been completed, it is desirable to avoid completely filling the holes on the circuit board with solder. After the circuit board is installed in the oscilloscope chassis, these holes will be used to permanently wire the board into the circuitry of the oscilloscope.

In this project you will assemble the Vertical Amplifier and prepare the assembled board for the tests that follow.

Figure 1-1 is a simplified block diagram of the Bell & Howell IOD-4540 Oscilloscope. Most of the circuitry of the oscilloscope (scope) is mounted on four printed circuit boards: the Vertical Amplifier Circuit Board, the Horizontal Amplifier Circuit Board, the Sweep/Trigger Circuit Board, and the Power Supply Circuit Board.

The input signal is fed thru the Vertical Input Attenuator to the Vertical Amplifier Circuit Board. The Vertical Amplifier amplifies the vertical input signal before it is applied to the vertical deflection plates of the Cathode Ray Tube (CRT). In addition, the vertical input signal is processed and then applied to the Sweep/Trigger Circuit Board.

The Sweep/Trigger circuitry is triggered by the signal from the Vertical Amplifier Circuit Board. As the Sweep/Trigger circuitry is triggered, it produces the Unblanking pulse, which is applied to the cathode of the CRT. This causes the CRT to unblank during sweep time. The Sweep/Trigger circuitry also produces the Retrace Blanking pulse. This pulse is applied to the control grid of the CRT, causing the trace to be blanked during retrace time. The Sweep/Trigger circuitry also produces the Sweep Ramp Signal which is applied to the ramp generating circuitry. For simplicity, the ramp generating circuitry is not shown in Figure 1-1. However, the ramp generator circuit can be considered to be part of the Horizontal Amplifier circuitry. The output signal from the ramp generating circuit is amplified by the Horizontal Amplifier Circuit Board and applied to the horizontal deflection plates of the CRT.

In certain applications of the oscilloscope, it may be necessary to apply an external trigger signal or an external horizontal input signal. For this reason, the IOD-4540 has both an external trigger input (EXT. TRIG INPUT) and an external horizontal input (EXT. HORIZ INPUT) capability. The operation of these two inputs is covered in detail later on.

Figure 1-2 is the functional block diagram of the Vertical Amplifier Circuit Board. The vertical input signal is applied to the Input Attenuator through switch SW1 (AC/GND/DC). When SW1 is in the AC position, a dc blocking capacitor is in series with the attenuator input circuit. This capacitor prevents any dc voltage from being applied to the Input Attenuator. When switch SW1 is placed in the ground (GND) position, the input to the attenuator is shorted to ground. When switch SW1 is in the DC position, any dc voltage applied to the vertical input will be applied to the input of the attenuator. The DC position of SW1 allows the scope to be used for measuring dc voltage levels.

The Input Attenuator is used to control the amplitude of the input signal to the Input Follower, Q101. The output of the Input Follower is fed through the Vertical Calibration (VERT. CAL.) control to the input of the Output Attenuator. The VERT CAL control is adjusted to vary the amplitude of the vertical signal to compensate for differences in the gain of the amplifiers that follow. This allows signals of specific amplitude to cause specific amounts of vertical beam deflection. The signal from the resistive network Output Attenuator is applied to the Output Follower, Q103. The Output Follower isolates the Output Attenuator from Amplifier Stage Q105, Q106. The amplified signal from the amplifier stage is coupled to the Driver Stage, Q107, Q108 for further amplification before it is applied to the Output Stage, Q109, Q110. The signal from the Output Stage is then applied to the Vertical Deflection plates of the CRT, which causes vertical deflection of the electron beam. Emitter Follower Q111 provides a sample of the output signal to the Sweep/Trigger Circuit Board.

The schematic diagram of the Vertical Amplifier Circuit Board and most of its associated circuitry is shown in Figure 1-3. As can be seen in Figure 1-3, the IOD-4540 uses direct coupling between stages. Thus, DC voltage measurements can be made with the IOD-4540 when the AC/GND/DC switch is in the DC position.

The signal waveform to be observed is applied to the Vertical Input jack. If it is desired to measure a dc voltage, SW1 must be in the DC position, as shown in Figure 1-3. When SW1 is in the AC position, C7 is switched into the input circuitry. Capacitor C7 blocks any dc component in the input signal while allowing ac variations to be applied to the Input Attenuator.

The purpose of the Vertical Input Attenuator is to reduce the amount of input signal to the vertical amplifiers. A resistor voltage divider network, R1 through R3, is used to divide an input voltage down to a level that will not overdrive the amplifiers.

To maintain a flat frequency response over a 5 MHz bandwidth, the Vertical Input Attenuator is frequency compensated. This is accomplished by capacitors C2A, C2B, C2C, and C3. Switch SW2A (VOLTS/CM) is used to select the desired amount of input signal that is fed through R101 to the gate of Q101.

The output signal of the Input Attenuator is a portion of the input signal. That portion of the input signal is fed through R101 and C101 to the gate of the Source Follower, Q101. R101, in conjunction with Input Limiter ZD101 and ZD102, protects the input of Q101. Capacitor C101 improves the high frequency response of the input circuit.

One function of Q102 is to provide a constant current source for Q101. As a signal is applied to the gate of the Source Follower, Q101, its internal impedance changes. Since the current through Q101 is constant and its internal impedance changes with the input signal, the signal variations appear at the source of Q101.

The Vertical DC Balance control (VERT DC BAL), R103, adjusts the current through Q102 to set Q101's source voltage to zero volts. The source voltage of Q101 is adjusted to zero volts with no signal applied to the Vertical Input. When R103 is properly adjusted, the CRT trace will not move up or down when the Variable Gain (VAR GAIN) control is adjusted. The output signal from Q101 is coupled through the Vertical Calibration control (VERT CAL), R102, to the Variable Gain (VAR GAIN) control R4, located on the oscilloscope's front panel.

The output from the Variable Gain control is taken from the wiper of R4 and applied to voltage divider network R5, R6, and R7, which is the Output Attenuator. The Output Attenuator switch, SW2B, which is mechanically ganged to the Input Attenuator Switch, SW2A, selects the amount of attenuation and direct couples the signal to the gate of Output Follower Q103.

The signal from Q103 is then applied to the base of Q105, which is the input to the first of three differential amplifier stages. Q106 and its associated circuitry comprise the other half of the first differential Amplifier Stage.

Q104 and its associated components serve as a constant current source for the first differential Amplifier Stage. The operation of Q104 is very similar to that of Q102.

The amplified output from the first differential Amplifier Stage, Q105 and Q106, is then fed to the differential Driver Stage, Q107 and Q108, for further amplification before being applied to the differential Output Stage, Q109 and Q110. Additional amplification takes place in the differential Output Stage. The signals at the collectors of Q109 and Q110 leave the circuit board at points S and M, respectively, and are applied to the vertical deflection plates of the CRT.

Q111 is an emitter follower which receives its input signal from the emitter of Q109. The output of this stage is taken from the wiper of DC LEVEL control R128, and applied to the Sweep Trigger Circuit Board. The signal from the wiper of R128 is actually a sample of the vertical amplifier board output signal. The DC LEVEL control, R128, is set so that a signal of proper amplitude is applied to the Sweep Trigger Circuit Board. Further details of the purpose of this signal are contained in Project 3.

PLATE VOLTS ADJ control R108, in the emitter circuit of Q104, is used to set the current through Q104, which in turn sets the total current through the differential stages. The total current through the differential amplifier stages remains constant at all times. When a signal is applied, a change in current in one half of a differential amplifier stage will occur. This change in current will be offset by an equal but opposite change in the other half of the stage.

By varying the PLATE VOLTS ADJ. control, the total current to the differential Amplifier Stage Q105 and Q106 varies, which in turn controls the collector current and voltage of both the driver and output differential stages. This is accomplished because all of the stages are direct coupled. Therefore, changing the current in one stage changes the current in all of the following stages. Consequently, adjusting PLATE VOLTS ADJ control sets the dc voltage at the collectors of Q109 and Q110 to the desired value.

VERTICAL POSITION ADJ (adjust) control R111, and front panel control R8 (VERTICAL POSITION), affect the balance of the differential stages by directly affecting the bias of Q106, Q108 and Q110. R8 is used as a fine position control, while R111 is used as a coarse position control. Once R111 has been properly adjusted, it is usually unnecessary to readjust it in normal use.

By adjusting either R8 or R111, the balance of each of the differential amplifiers is affected. This, in turn, affects the vertical position of the trace on the face of the CRT.

PROCEDURE

BUILDING THE VERTICAL AMPLIFIER CIRCUIT BOARD

1. The components for the assembly of the Vertical Amplifier Circuit Board are included in shipment WBS-1. For your convenience, the components for each board have been packaged separately. DO NOT open all of the packages at once. Open only the packages that contain components for the Vertical Amplifier Circuit Board. These packages are listed on page 11 of the assembly manual.

2. Refer to the Assembly and Operation Manual which provides step-by-step instructions for building the Vertical Amplifier.

3. The list of components required for the assembly of the Vertical Amplifier Circuit Board is on pages 11 through 13 of the assembly manual. Check the parts you received in shipment WBS-1 against the parts list to ensure that you received all of the required parts. If any part is missing or defective, follow the instructions in the assembly manual to obtain a replacement part.

4. Follow the assembly procedures given on pages 14 through 19 of the Assembly and Operation Manual. Be sure your soldering iron is clean and properly tinned. Take your time and be sure that all components are properly installed and all solder connections are properly made. The Vertical Amplifier Circuit Board

has some connections that are rather close. So be careful to avoid solder bridges across foil conductors.

5. After you have completed the assembly of the Vertical Amplifier Circuit Board, visually inspect the board to see that all connections have been properly made and soldered. Then procede with the following steps in this project.

TEST NO. 1

PRELIMINARY RESISTANCE CHECKS

In this procedure you will check your wiring and installation of components on the board before making voltage measurements. If a mistake was made in the installation of components, damage could result when the operating voltages are applied. For this reason, it is a good idea to check the dc resistance of circuits on the board before applying power to the board. This will help you determine if there are any assembly errors and minimize the chance that operating voltages may damage components on the board.

PROCEDURE

1. Begin by preparing the appropriate wire lengths shown in Table 1-1. To prepare the wires, cut them to the correct lengths, then strip 1/4" of insulation from one end and 1/2" of insulation from the other end. After the wires are prepared, tack solder the 1/4" end into the PC board at the points indicated in Table 1-1. These wires will be removed when you have finished the experiments.

2. Arrange 13 modular connectors and install the PC board as shown in Layout 1-1. NOTE: Be sure to position the board so that the part number is in the lower right hand corner as shown.

3. Insert a wire in each modular connector. Be sure the wire from each lettered point is inserted in the appropriately lettered modular connector. NOTE: The black wire coming from point P should not be connected to a modular connector. Also, the shielded cable coming from point K should be coiled. A piece of hookup wire should be wrapped around the coil to keep it together before it is installed in the modular connector.

4. Clip the black lead of your DMM to the black wire connected at point P on the PC board.

5. Set each variable control to its center of rotation.

6. Measure the resistance at all the lettered points indicated in Table 1-2. These measurements should be made at the appropriate modular connectors as indicated in Layout 1-1. All resistances should be within 20% of those listed in Table 1-2.

If the resistance at any point is more than 20% higher or lower than that shown in Table 1-2, look for an error in assembly. For example, a reading of approximately 12 kΩ at point F may indicate that the emitter and collector leads of Q102 are shorted. Another possibility is that there is a solder bridge across the points at which these two wires are soldered to the board. Whenever a higher than normal reading is encountered, it could indicate that a transistor or diode is installed backwards.

After all resistances have been checked and found to be within tolerance, remove the DMM clip lead from the wire at point P, but leave the wire connected to this point. Then continue with the following steps in this manual.

ANALYSIS: TEST NO. 1

1. If D103 were shorted, what would the DMM indicate when the resistance was measured at point A? Why? (Refer to Figure 1-3)

2. If the dc resistance from G to ground (point P) were 1.2 kΩ or less, would the Vertical Amplifier Circuit Board operate properly when power was applied? Why? (Refer to Figure 1-3)

PRELIMINARY SETUP

1. Prepare nine lengths of wire following Table 1-3. Strip 1/4" of insulation from one end and 1/2" of insulation from the other end.

2. Prepare the 5 kΩ and 1 megΩ potentiometers (pots) as shown in Figure 1-4.

3. Install a 1 kΩ, 1/2W resistor between modular connectors A and U.

4. Install and connect the 5 kΩ pot as shown in Layout 1-2. Set the 1 MEG pot aside. It will be installed later on.

5. Prepare a 7-1/2" length of black wire. Strip 1/2" of insulation from both ends. Connect the wire between the (-) REG DC terminal and the 0V AC terminal on the design console.

6. Construct the -9V power supply enclosed within the dashed line of Layout 1-2. D1 and D2 are silicon diodes; C1 is a 1000 μF, 50V DC electrolytic capacitor. Be sure that the components are properly polarized, as shown.

7. Turn on the design console and check the output of the supply to make sure that the voltage amplitude and polarity are correct.

8. Set the output of the REG DC supply for +9V reading.

9. Turn off the design console.

10. Connect the red wire coming from point G on the PC board to the + REG DC terminal.

11. Construct the rest of Layout 1-2.

12. Double check your work. Make sure that all wiring is connected as shown in Layout 1-2. Be certain that the 5 kΩ pot is connected properly. To reduce the chance that damage may occur to the circuit board, make sure that the two 2.2 kΩ resistors are connected in parallel between the +180 volt supply and the white wire connected to point R on the PC board.

13. Connect the black DMM lead to the REG DC (-) terminal which will serve as circuit ground. All resistance and voltage measurements are now made with respect to ground simply by touching the red meter prod to the point indicated.

14. Set all variable controls, including the 5 kΩ pot, to the center of rotation.

ANALYSIS: PRELIMINARY SETUP

1. Will varying the 5 kΩ pot, which is in the place of the VERTICAL POSITION control R8, have an effect on the voltage at point S? Why?

2. Assume that the differential Amplifier Stage (Q105, Q106) is balanced. When the wiper of R108 (PLATE VOLTS ADJ) is adjusted from the center

position toward lug 1, will there be any effect on the dc voltages at points S and M? If so, what will be the effect?

TEST NO. 2

PRELIMINARY CALIBRATION

In this test you will perform a preliminary calibration procedure on the circuit board. (A more precise calibration procedure is performed when the scope is fully constructed.) Refer to Figure 1-5 for the following steps.

1. Make sure each variable control is set to its center of rotation.

2. Measure the dc voltage at the front lug of the VERT CAL control (source of Q101) and adjust the DC BAL (DC Balance) control to obtain a zero volt reading. Check for both a positive and negative voltage.

3. Set the voltmeter to measure 150 volts DC.

4. Alternately measure the voltage at the metal tabs on top of transistors Q109 and Q110. Adjust the 5 kΩ pot until both transistor voltages are the same. Be sure to allow meter reading to stabilize. NOTE: As the voltage on one transistor decreases, the voltage on the other transistor increases. If this does not occur, a slight adjustment of VERT POS ADJ control on the board may be necessary. Since there is an interaction between the 5K pot and the VERT POS ADJ, you will have to adjust these controls until the voltages are the same.

5. Again, measure the voltage at the metal tab on top of transistors Q109 and Q110. Turn the PLATE VOLTS ADJ control to obtain 80 volts at the metal tab. NOTE: If the voltage at both transistor tabs is not the same, repeat step 4, then return to this step.

6. Turn off the design console.

ANALYSIS: TEST NO. 2

1. The first step in Test 3 was to set the VERT DC BAL control for zero volts dc at the front lug (lug 1) of VERTICAL control R102. Why is this necessary?

2. Why is it necessary to adjust both the 5 kΩ pot and the VERT POS ADJ, R111, in order to balance the dc voltages at points S and M?

TEST NO. 3

AC SIGNAL TRACING

In this test we will be applying a signal to the board and tracing the signal through the stages. Be sure that Test No. 2 has been completed before starting this test.

1. Locate the 1 megΩ pot and mount it as shown in Layout 1-3.

2. Connect the leads of the 1 megΩ pot as indicated in Table 1-3.

3. Remove the 2" red jumper wire connected between modular connectors D and P.

4. Turn the 1 megΩ pot fully clockwise.

5. Set the design console frequency adjustment control to midrange. Turn on the design console.

6. Set your DMM to measure .10 VAC. Be sure the meter ground is connected to circuit ground (-REG DC).

7. Connect the red DMM lead to point D. NOTE: When making signal voltage measurements in the following steps, allow the DMM reading to settle, when necessary.

8. Adjust the 1 megΩ pot for a .10 volt reading at point D.

9. Measure and record the ac signal voltage at points F, H. ____________ volts.

10. Calculate the voltage gain of Q101. ___________

11. Measure and record the ac signal voltage at the base of Q105 by touching the red DMM probe to point 1 (Refer to Figure 1-6). _____________ volts.

12. Measure and record the ac signal voltage at the collector of Q105 by touching the red DMM probe to point 2 (Refer to Figure 1-6.) __________ volts.

13. Calculate the gain of Q105. ___________

14. Measure and record the ac signal voltage at the collector of Q107 by touching the red DMM probe to point 3 (Refer to Figure 1-6). ____________ volts.

15. Calculate the gain of Q107. ________________

16. Measure and record the ac signal voltage at the collector of Q109 by touching the red DMM probe to point S (Refer to Layout 1-3). ________________

17. Calculate the gain of Q109. ___________________

18. Calculate the overall gain of the Vertical Amplifier Circuit Board.

____

ANALYSIS: TEST NO. 3

1. Assuming that the differential stages are properly balanced, should the signal voltage at point M equal the signal voltage at point S? Why?

2. Measure the signal voltage at point M (allow the meter reading enough time to settle.) Are the signal voltages equal at points S and M? If not, why?

Turn off the design console. Remove the PC board from the design console and dismantle the circuit. Unsolder all temporary wires (see Table 1-1) and remove the excess solder from the PC board. NOTE: DO NOT remove the twin lead or the shielded cable connected to points K & L. Set the Vertical Amplifier Circuit Board aside.

PROJECT 1: ANALYSIS ANSWERS

TEST NO. 1

1. ZeroΩ, because the shorted diode acts as a piece of wire between point A and circuit ground (point P).

2. No, because 1.2 kΩ is much lower than the normal resistance. The lower reading indicates a short exists in the +9V load circuitry, which will prevent proper circuit operation.

PRELIMINARY SETUP

1. Yes, because varying the 5K pot changes the voltage at the base of Q106, which affects the balance of the three differential stages.

2. Yes, the voltage at points S and M all decrease.

TEST NO. 2

1. If any voltage other than zero volts dc is present, it will not be possible to properly balance the differential amplifier stages.

2. The 5K pot, which is acting as a vertical position control, and R111 form a voltage divider. Therefore, the setting of either of these controls will affect the bias of Q106. This affects the balance of the differential stages, which affects the voltage at points S and M.

TEST NO. 3

1. Yes, because the gain of both sections of the balanced differential amplifiers should be the same.

2. Keep in mind that the differential amplifiers were balanced under static (no signal) conditions. Therefore, any minor variation in signal amplitude is the result of dynamic unbalance in the differential amplifiers. This unbalance is caused by component tolerances.

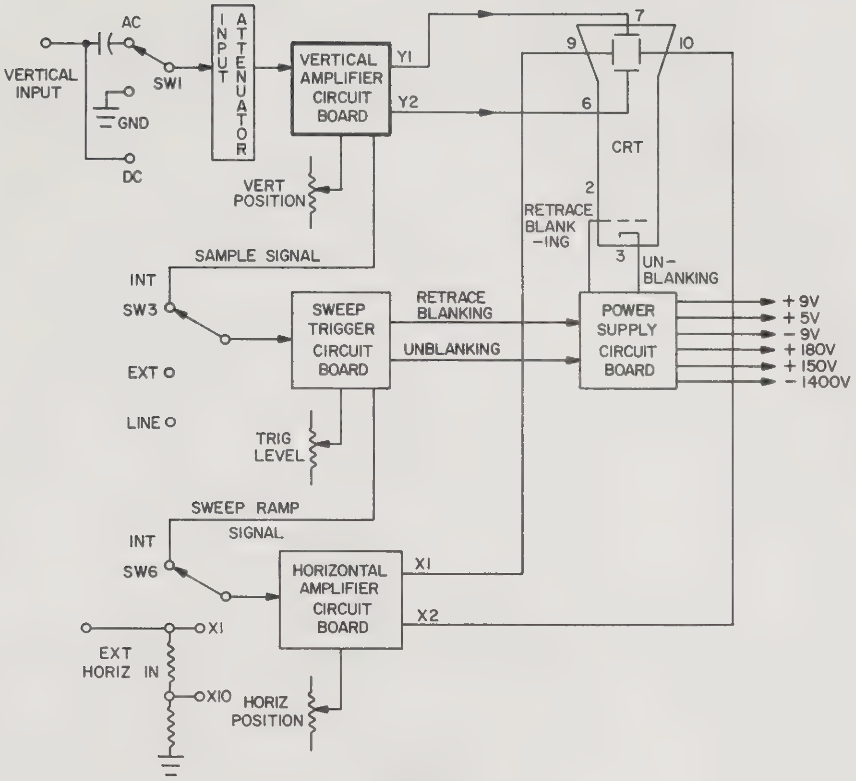


FIGURE 1-1

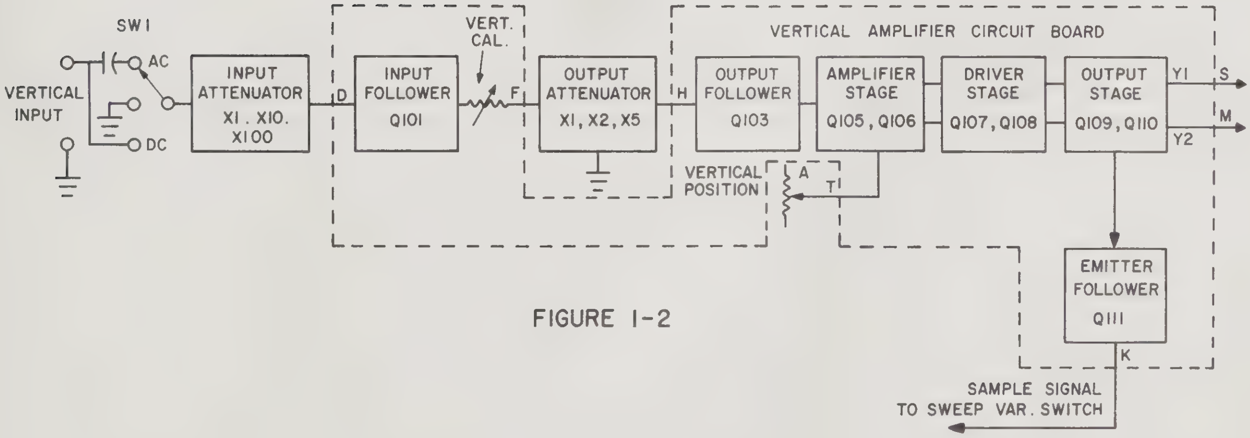


FIGURE 1-2

Figure 1-3 is a foldout and is inserted in the back of this Manual.

FIGURE 1-3

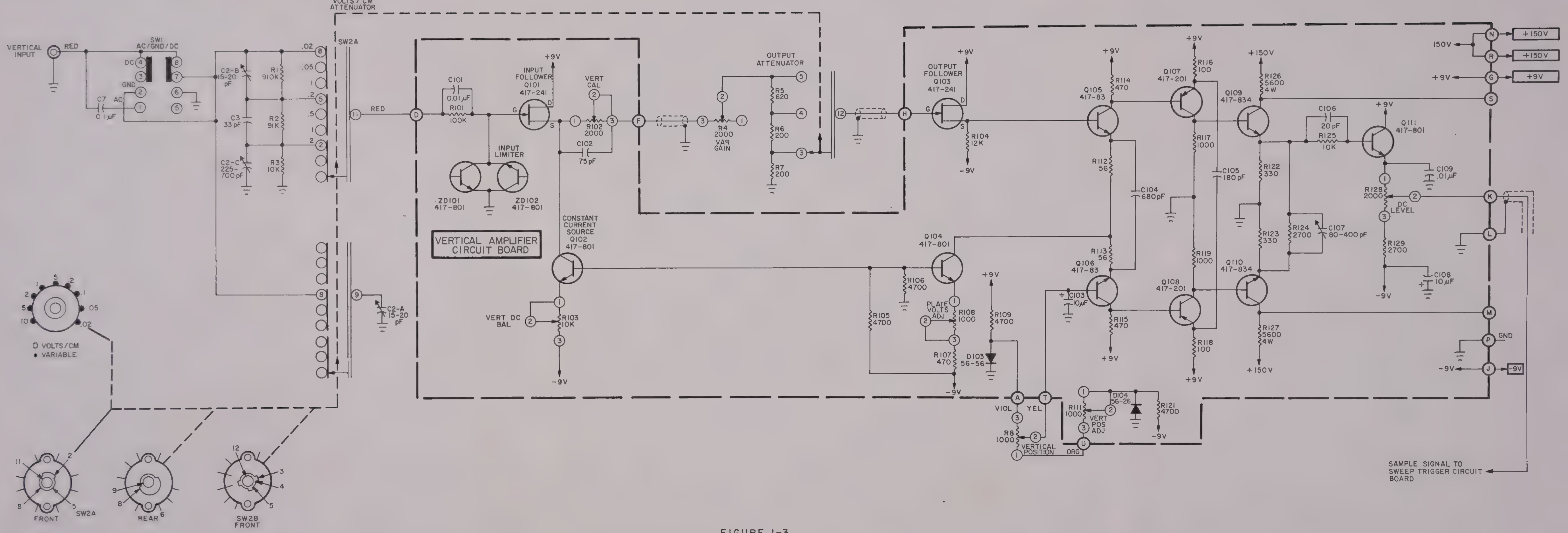
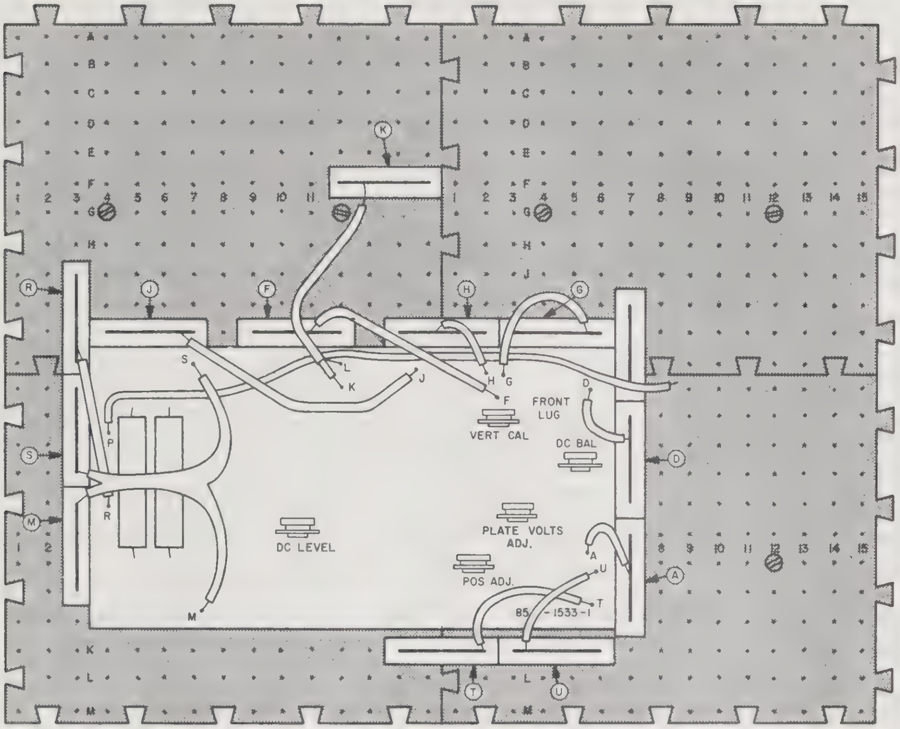

VERTICAL INPUT
RED
SW1 AC/GND/DC
DC
GND
AC
C7 0.1 µF
C2-B 15-20 pF
C3 33 pF
C2-C 225-700 pF
R1 910K
R2 91K
R3 10K
.02
.05
.1
.2
.5
1
2
VOLTS / CM ATTENUATOR
SW2A
RED
C101 0.01 µF
R101 100K
INPUT FOLLOWER Q101 417-241
+9V
G
D
S
VERT CAL
R102 2000
C102 75 pF
INPUT LIMITER
ZD101 417-801
ZD102 417-801
VERTICAL AMPLIFIER CIRCUIT BOARD
CONSTANT CURRENT SOURCE Q102 417-801
VERT DC BAL
R103 10K
-9V
C2-A 15-20 pF
0 VOLTS/CM
• VARIABLE
R4 2000 VAR GAIN
OUTPUT ATTENUATOR
R5 620
R6 200
R7 200
OUTPUT FOLLOWER Q103 417-241
R104 12K
Q104 417-801
R105 4700
R106 4700
PLATE VOLTS ADJ
R108 1000
R107 470
R109 4700
D103 56-56
Q105 417-83
R114 470
R112 56
R113 56
C104 680 pF
Q106 417-83
C103 10 µF
R115 470
Q107 417-201
R116 100
R117 1000
C105 180 pF
R119 1000
Q108 417-201
R118 100
Q109 417-834
R126 5600 4W
R122 330
R123 330
R124 2700
C107 80-400 pF
Q110 417-834
R127 5600 4W
+150V
C106 20 pF
R125 10K
Q111 417-801
C109 .01 µF
R128 2000
DC LEVEL
R129 2700
C108 10 µF
150V
+150V
+9V
GND
-9V
VIOL
YEL
ORG
R8 1000
VERTICAL POSITION
R111 1000
VERT POS ADJ
D104 56-26
R121 4700
SAMPLE SIGNAL TO SWEEP TRIGGER CIRCUIT BOARD
FRONT
SW2A
REAR
SW2B FRONT

FIGURE 1-3



LAYOUT 1-1

QUANTITY	COLOR	LENGTH	POINT
1	Brown	3"	T
1	Yellow	3"	U
1	Yellow	5"	J
1	Red	3"	A
1	Red	6"	G
3	Blue	3"	D, F, H
1	Black	3"	P
1	White	3"	R

TABLE 1-1

POINT	RESISTANCE	YOUR READING
Point T	15.5 kΩ	
Point U	16.0 kΩ	
Point A	75Ω	
Point D	170 kΩ	
Point G	9.5 kΩ	
Point F	20 kΩ	
Point H	14.8 kΩ	
Point J	9.5 kΩ	
Point R	∞	
Point S	∞	
Point M	∞	
Point K	13.4 kΩ	

TABLE 1-2

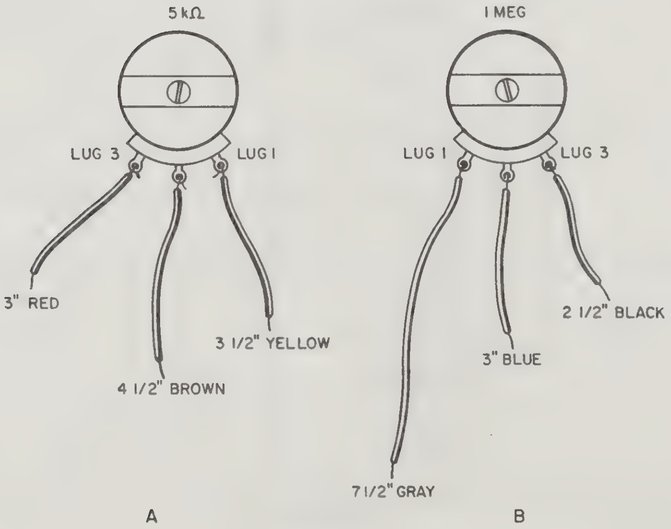


FIGURE 1-4

QUANTITY	COLOR	LENGTH	POINT
1	Yellow	3-1/2"	5 kΩ Lug 1 to U
1	Brown	4-1/2"	5 kΩ Lug 2 to T
1	Red	3"	5 kΩ Lug 3 to A
1	Black	2-1/2"	1 meg Lug 3 to P
1	Blue	3"	1 meg Lug 2 to D
1	Gray	7-1/2"	1 meg Lug 1 to ∿
1	Red	2" *	D to P
1	White	4-1/2" *	+180 to 1.5 kΩ
1	Black	5-1/2" *	0 VAC to P

TABLE 1-3

* Strip 1/2" of insulation from both ends.

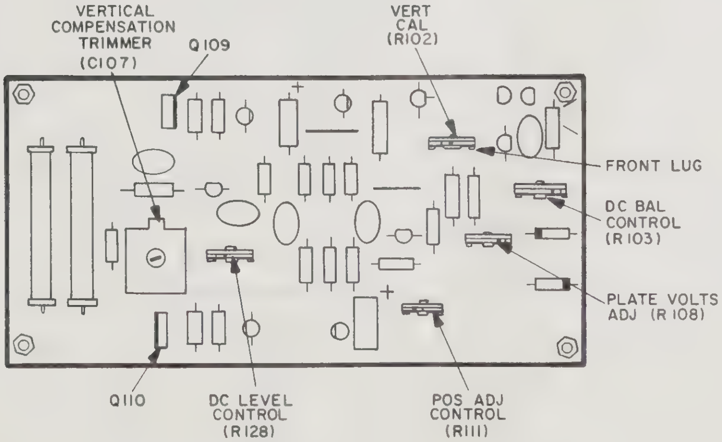
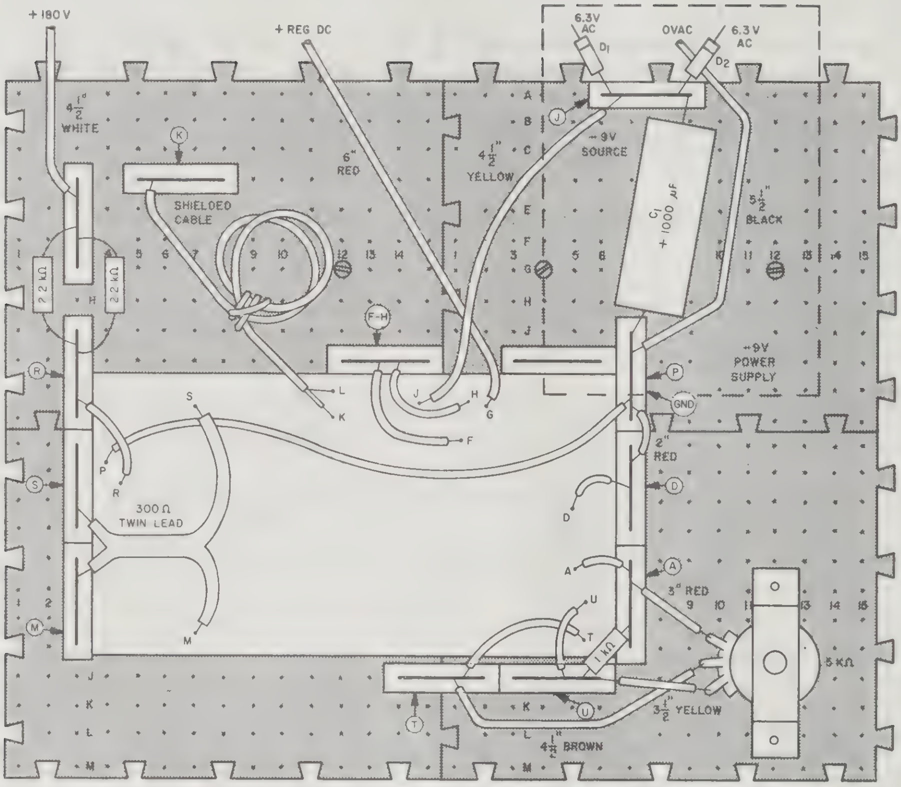


FIGURE 1-5



LAYOUT I-2

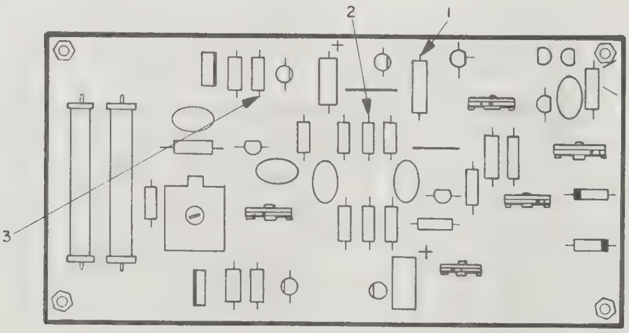
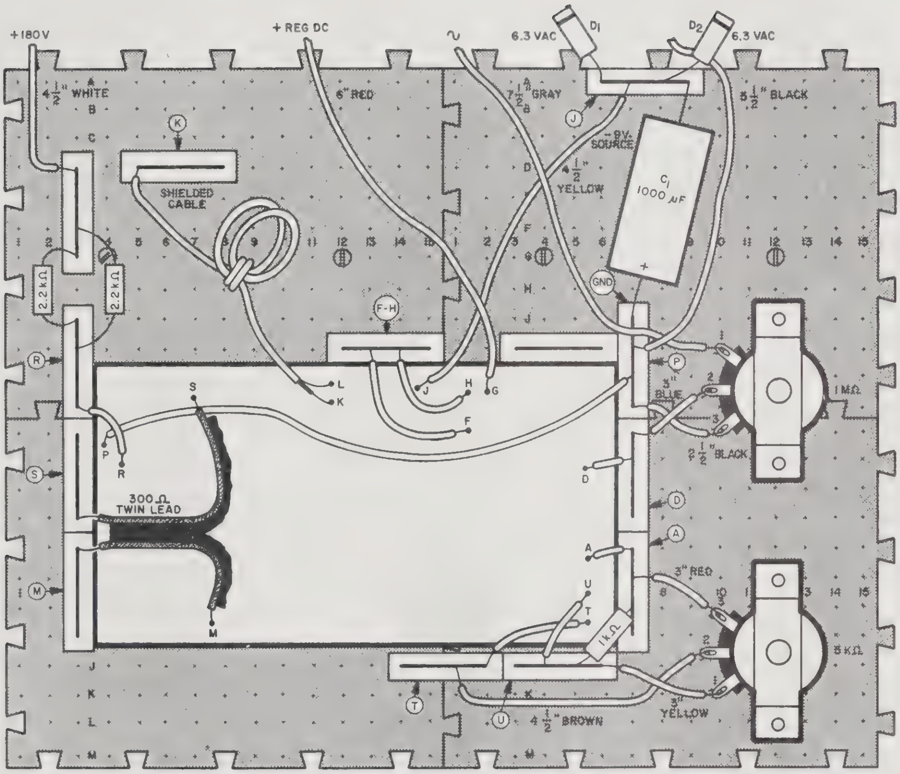


FIGURE I-6


+180V
+REG DC
∿
6.3 VAC
D1
D2
6.3 VAC
4 1/2" WHITE
6" RED
7 1/2" GRAY
5 1/2" BLACK
K
SHIELDED CABLE
J
-9V SOURCE
4 1/2" YELLOW
C1 1000 µF
+
GND
2.2 kΩ
2.2 kΩ
F-H
R
P
3" BLUE
1 MΩ
2 1/2" BLACK
L
K
J
H
G
F
S
P
R
300 Ω TWIN LEAD
S
D
D
A
A
3" RED
U
T
1 kΩ
5 kΩ
M
M
T
U
4 1/2" BROWN
3" YELLOW

LAYOUT 1-3

PROJECT 2

HORIZONTAL AMPLIFIER CIRCUIT BOARD

PARTS NEEDED

IOD-4540 Horizontal Amplifier Circuit Board Assembly Parts

- 2 - Silicon Diodes
- 1 - 1000 μF, 50V DC Electrolytic Capacitor
- 11 - Modular Connectors
- 1 - 1 MegΩ Pot
- 1 - 5 kΩ Pot
- 1 - 1 kΩ, 1/2W Resistor
- 1 - 4700Ω, 1/2W Resistor

DISCUSSION

In this project you will assemble the Horizontal Amplifier Circuit Board for your Bell & Howell Model IOD-4540 Oscilloscope. As in the previous project, it will be necessary to solder several temporary wires to the circuit board in order to perform the various tests included in this project.

Notice, in the simplified block diagram of the scope in Figure 2-1, that the input to the HORIZONTAL AMPLIFIER CIRCUIT BOARD can be switched to either an internally or an externally generated signal. In either case, the output sweep signal will be applied to the horizontal deflection plates of the CRT.

The simplified block diagram of the Horizontal Amplifier Circuit Board is shown in Figure 2-2. When the input switch (SW6) is in the internal position, the Sweep Ramp signal is applied to Input Follower Q201. Actually, the input switch is a rotary switch having several internal sweep positions. However, for simplicity, only one position is shown in Figure 2-2.

When the input switch is in the EXT IN (external input) position, an external input signal can be applied to the input follower. The input switch is placed in the EXT IN position when it is desired to use the scope for special applications. For example, an external sinewave can be used to form a Lissajous pattern on the scope when another signal is applied to the vertical deflection plates.

The operation of the Horizontal Amplifier Circuit Board is similar to the operation of the Vertical Amplifier Circuit Board. The signal from Q201 is coupled through the SWEEP LENGTH control and the horizontal gain (HORIZ. GAIN) control to Output Follower Q203. The HORIZ. GAIN control is located on the front panel.

The signal from the Output Follower is applied to the differential Amplifier Stage, Q205 and Q206, before it is sent to the differential Output Stage, Q207 and Q208. Notice that the HORIZ. POSITION control is part of the Amplifier Stage. The sweep signals from the Output Stage leave the circuit board at points K and J and are applied to the horizontal deflection plates of the CRT.

Figure 2-3 is the schematic diagram of the Horizontal Amplifier Circuit Board. The input signal is normally the sweep signal that is internally generated across one of the sweep capacitors (C8 to C13). This signal is controlled by Q310 on the Sweep/Trigger Circuit Board, which serves as an electronic switch. Q310 is normally cut off. This initiates the Sweep Ramp Signal to the Horizontal Amplifier Circuit Board by allowing the selected sweep capacitor to charge. The charge path for the selected capacitor is through SW6A to the collector of Q1, then through Q1 to its emitter. Charge current then flows from the emitter of Q1 through the selected fixed sweep resistor, (R15, R16 or R17) the SWEEP VARIABLE control, R14, to the +8.8V supply on the SWEEP/TRIGGER CIRCUIT BOARD. Since Q1 is a constant current source, the selected sweep capacitor will charge at a linear rate, generating a slope that is part of the Ramp Sweep signal.

When the wiper of R14 is making contact with lug 1, the sweep is calibrated to the sweep rate selected by the TIME/CM switch. This setting of the control corresponds to the CAL (calibrated) position. As the wiper of R14 is moved toward lug 3, the sweep speed decreases because the ramp slope decreases. Thus, it is possible to adjust the sweep for almost any desired sweep rate. For example, with the TIME/CM switch in the 2 mS position, the sweep rate can be varied from 2 mS/CM (CAL position of the SWEEP VARIABLE control) to 20 mS/CM, which is the next slowest TIME/CM switch position. Therefore, by applying a known frequency signal to the VERTICAL INPUT jack, the sweep rate can be set to almost any desired sweep rate. For example, if a 1 kHz signal is applied to the scope and the TIME/CM and the SWEEP VARIABLE control are set so that one cycle occurs within one centimeter, the sweep rate is then set for 1 mS/CM.

When a positive pulse is applied to Q310's base, Q310 will saturate, effectively grounding the collector of Q1. Since the collector of Q1 is electrically the same point as the collector of Q310, the selected sweep capacitor will rapidly discharge through Q310 to ground. At the end of the positive pulse on the base of Q310, Q310 cuts off and the ground is removed from the collector of Q1. This will allow the timing capacitor to start to recharge.

The sweep rate is varied by changing the setting of the TIME/CM switch, SW6. The setting of the TIME/CM switch controls the sweep rate by selecting predetermined resistor and capacitor combinations (R15, R16, R17 and C8 to C13). The selected combination determines the RC time constant and the sweep rate.

The generated Sweep Ramp signal is fed from switch SW6 to the gate of INPUT FOLLOWER Q201. The Input Limiter, which is located in the gate circuitry of Q201, limits the input signal amplitude at the Q201 gate of 18V p-p. Q202 is a constant current source for Q201. The HORIZ DC BAL (Horizontal DC balance) control, R203, is adjusted for zero volts at the source of Q201 under no signal conditions. The output of Q201 is coupled through the SWEEP LENGTH control, R202, and SW6A to the gate of Output Follower Q203.

The HORIZ GAIN control, R21, is switched into the circuit whenever TIME/CM switch is placed in either of the EXT IN (external input) positions. The HORIZ GAIN control, which is a front panel control, allows you to set the sweep to a desired length across the face of the CRT when using an externally generated sweep signal.

The output signal from Q203 is fed to the first of two differential amplifier stages. The first stage consists of Q205 and Q206. The PLATE VOLTS ADJ Control, R208, in the emitter circuitry of the Constant Current Source, Q204, establishes the collector current of Q204. This current establishes the total current through the differential Amplifier Stage, Q205 and Q206. The total current in the differential Amplifier Stage is constant at all times. For example, when an applied signal causes the current through Q205 to increase, the current through Q206 will decrease by the same amount. By varying the PLATE VOLTS ADJ. control, the total current to Q205 and Q206 is varied, which in turn controls the collector voltage of both halves of this stage. The collector voltages of Q205 and Q206 control the bias voltages and collector currents of Output Stage Q207 and Q208. Consequently, the collector voltages of Q207 and Q208 are varied when the PLATE VOLTS ADJ. control is properly adjusted. The PLATE VOLTS ADJ control is properly adjusted when +90V is present at the collectors of Q207 and Q208 under no signal conditions.

The HORIZONTAL POSITION control, R22, is located on the front panel. This control sets the bias of Q206 and Q208 which, in turn, affects the balance of the differential stages. Varying this control affects the horizontal position of the sweep.

The output signal from Output Follower Q203 is applied to the differential Amplifier Stage and differential Output Stage for amplification before being applied to the horizontal deflection plates of the CRT. The output signals leave the Horizontal Amplifier Circuit Board at K and J.

PROCEDURE

BUILDING THE HORIZONTAL AMPLIFIER CIRCUIT BOARD

1. The components for the assembly of the HORIZONTAL AMPLIFIER Circuit Board are included in shipment WBS-1.

2. Refer to the Assembly and Operation Manual which provides step-by-step instructions for building the circuit board.

3. The list of components required for the assembly of the Horizontal Amplifier Circuit Board is on pages 21 through 23 of the assembly manual. Open the package that contains the components for the Horizontal Amplifier Circuit Board. Check the parts you received in shipment WBS-1 against the parts list on pages 21 through 23 to ensure that you received all of the required parts. If any part is missing or defective, follow the instructions in the assembly manual to obtain a replacement part.

4. Follow the assembly procedures given on pages 24 through 29 of the Assembly and Operation Manual. Be sure your soldering iron is clean and properly tinned. Take your time and be sure that all components are properly installed and all solder connections are properly made. The Horizontal Amplifier Circuit Board has some connections that are rather close. So be careful to avoid solder bridges across foil conductors.

5. After you have completed the assembly of the Horizontal Amplifier Circuit Board, visually inspect the board to ensure that all connections have been properly made and soldered. Then procede with the following steps in this project.

TEST NO. 1

PRELIMINARY RESISTANCE CHECKS

In this procedure you will check your wiring and installation of components on the board before making voltage measurements. If a mistake were made in the installation of components, damage could result when the operating voltages are applied. For this reason, it is a good idea to check the dc resistance of circuits on the board before applying power to the board. This will help you locate any incorrect connection or defective components.

PROCEDURE

1. Begin by preparing the appropriate wire lengths shown in Table 2-1. To prepare the wires, cut them to the correct lengths and then strip 1/4" of insulation from one end and 1/2" of insulation from the other end. After the wires are prepared, tack solder the 1/4" end into the PC board at the points indicated in Table 2-1. These wires will be removed later on.

2. Arrange 11 modular connectors as shown in Layout 2-1, and install the PC board as shown in the layout. NOTE: Be sure to position the board with the part number in the lower right hand corner as shown.

3. Insert a wire in each modular connector. Be sure the wire from each lettered point is inserted in the appropriately lettered modular connector. NOTE: The black wire coming from point N should not be connected to a modular connector. Tack solder a 1" length of bare wire to the center conductor of the shielded cable from point F. This will provide electrical contact with the modular connector.

4. Clip the black lead of your DMM to the black wire connected at point N on the PC board.

5. Set all variable controls to their center of rotation.

6. Measure the resistance at all the lettered points indicated in Table 2-2. These measurements should be made at the appropriate modular connectors as indicated in Layout 2-1. All resistances should be within 20% of those listed in Table 2-2.

If the resistance at any point is more than 20% higher or lower than that shown in Table 2-2, look for an error in assembly. After all resistances have been checked and found to be within tolerance, continue with the following steps in this manual. Before proceeding, remove the DMM clip lead from the wire at point N, but leave the wire connected to this point.

ANAYLSIS: TEST NO. 1

1. If the INPUT LIMITER is shorted, what would be the approximate resistance at point D?

2. If Q203 were open, gate to source, what would be the resistance at point H?

PRELIMINARY SETUP

1. Construct circuit Layout 2-2.

2. Be sure to install the 1 kΩ resistor between modular connectors A and B.

3. Be sure the 5 kΩ pot is installed correctly, as shown in Layout 2-2.

4. Connect a black wire between REG DC (-) terminal and 0 VAC terminal.

5. DO NOT connect the output of the -9V power supply to the wire coming from M at this time.

6. DO NOT connect the output of the REG DC (+) power supply to the wire coming from G at this time.

7. DO NOT connect the white wire coming from point L to the +180V supply at this time.

8. Turn on the design console and measure the output of the -9V power supply at connector M, to make sure that the voltage amplitude and polarity are correct. NOTE: The voltage will probably measure slightly high when unloaded.

9. Adjust the output of the REG DC supply for +9V.

10. Turn off the design console and connect the yellow wire coming from point M on the PC board to the output of the -9V power supply. (connector M)

11. Connect the red wire coming from point G on the PC board to the REG DC (+) terminal.

12. Connect the white wire coming from point L on the PC board to the +180V terminal.

13. Double check your work. Make sure that all wiring is connected as shown in Layout 2-2. Be certain that the 5 kΩ pot is connected properly.

14. Connect the black DMM lead to the REG DC (-) terminal, which will serve as circuit ground.

15. Set all variable controls, including the 5 kΩ pot, to the center of rotation.

ANALYSIS: PRELIMINARY SETUP

1. If the base to emitter junction of Q207 opened, what would the voltage reading be at point K?

2. If R205, in the base circuitry of Q204, shorted, would the voltage at point K change? If so, how?

TEST NO. 2

PRELIMINARY CALIBRATION

In this test you will perform a preliminary calibration procedure on the circuit board. However, it will be necessary to recalibrate the board later.

1. Prepare a 3" length of black hookup wire and connect it between modular connectors D and N in Layout 2-2. Then refer to Figure 2-4 for the following steps.

2. Make sure all the variable controls are in the center of their rotation. Then turn on the design console.

3. Measure the dc voltage at the front lug of the SWEEP LENGTH control and adjust the DC BAL (DC BALANCE) control to obtain a zero volt reading. Check for both a positive and negative voltage.

4. Set the meter to measure a voltage of about 180 volts dc.

5. Alternately measure the Q207 and Q208 collector at the metal tab on top of each transistor. Adjust the 5 kΩ pot until the voltages are equal. NOTE: As the voltage on one transistor decreases, the voltage on the other transistor increases.

6. Again measure the voltage at the collector of transistors Q207 and Q208. Turn the PLATE VOLTS ADJ control to obtain 90 volts at the collectors. NOTE: If the voltage at both transistor tabs is not the same, repeat the previous step and then return to this step.

ANALYSIS TEST NO. 2

1. If D203 opens, would you be able to balance the output voltages at points K and J? Why?

2. As the wiper of the PLATE VOLTS ADJ control is moved towards lug 3, should the voltage at points K and J increase or decrease? Why?

TEST NO. 3

AC SIGNAL TRACING

In this test we will be applying a signal to the input of the board and tracing the signal through the stages. The test signal source will be the output signal from the design console sinewave generator. The Horizontal Amplifier Circuit Board normally processes the internally generated Sweep Ramp signal. However, the circuit board is capable of amplifying an external sinewave. For this reason, a sinewave input will provide a reliable test of circuit board operation. Be sure that Test No. 3 has been completed before starting this test.

1. Locate the 1 MΩ pot and install it as shown in Layout 2-3.

2. Connect the leads of the 1 MΩ pot as indicated in Layout 2-3.

3. Remove the 3" black jumper wire connected between modular connectors D and N.

4. Adjust the 1 MΩ pot fully clockwise.

5. Set the design console frequency adjustment control to mid range.

6. Set your DMM to measure .10 VAC. Connect the meter ground to circuit ground (-REG DC).

7. Measure the ac signal voltage at point D. NOTE: When making signal voltage measurements in the following steps, allow the DMM reading to settle, when necessary.

8. Adjust the 1 MΩ pot for a .10 volt reading at point D.

9. Measure and record the AC voltage at the Front Lug of the SWEEP LENGTH control. _____________ volts.

10. Calculate the voltage gain of Q201. ______________ .

11. Measure and record the signal voltage at point F, H. _____________ .

12. Measure and record the signal voltage at the base of Q205 by touching the red DMM probe to point 1 (Refer to Figure 2-4.) _____________ volts.

13. Measure and record the signal voltage at the collector of Q205 by touching the DMM probe to point 2 (Refer to Figure 2-4.) ______________ volts.

14. Calculate the gain of Q205. ______________ .

15. Measure and record the signal voltage at the collector of Q207 by touching the DMM probe to point K.(Refer to Figure 2-4.) _______________ volts.

16. Calculate the gain of Q207. ________________ .

17. Calculate the overall gain of the Horizontal Amplifier Circuit Board.

______________ .

TEST NO. 3

1. Should the signal amplitude at the source of Q201 be the same as the signal amplitude at the gate? Why?

2. Should the signal voltage at the source of Q201 be different than the signal voltage at the gate of Q203 if the wiper of R202 is making contact with lug 3? If so, by how much? If not, why?

Turn off the design console. Remove the PC board from the design console and dismantle the circuit. Unsolder all temporary wires (see Table 2-1) and remove the excess solder from the PC board. NOTE: DO NOT remove the twin lead or the shielded cables. Set the Horizontal Amplifier Circuit Board aside.

ANALYSIS ANSWERS

PROJECT 2

TEST NO. 1

1. 100 kΩ, because you are measuring across R201, a 100 kΩ resistor.

2. Infinity, because there would be an open circuit to ground.

PRELIMINARY SETUP

1. 180V, because there is an open in the circuitry. As a result, there is no current in the circuit and no voltage drop across R219.

2. Yes, the voltage at point K would decrease. If R205 shorted, -9V would be present at the base of Q204, causing Q204 to cut off. Therefore, Q205 and Q206 would also be cut off, and approximately +9 volts would be present at their collectors. The +9 volts would be applied to the bases of Q207 and Q208, causing them to saturate. As a result, the collector voltages of these transistors will decrease to nearly zero volts. Since point K is tied to the collector of Q207, the voltage at point K will also decrease.

TEST NO. 2

1. No, becasue a much higher than normal positive voltage would be present at point A. This would cause unbalance in the differential amplifier circuits that the HORIZ POS control could not correct.

2. Decrease, because rotation of the wiper of PLATE VOLTS ADJ control, R208, toward lug 3 reduces Q204's conduction. As a result, the conduction of Q205 and Q206 decreases, causing their collector voltages to increase. These increased collector voltages increase the base voltages of Q207 and Q208, causing them to conduct more heavily. The increased conduction causes the collector voltages of Q208 and Q209 to decrease. Therefore, the voltage at points K and J will decrease.

TEST NO. 3

1. Yes, both signals should be the same or nearly the same, because Q201 is a source follower. Source followers have unity gain or slightly less than unity gain.

2. Yes, the signal amplitude at the gate of Q203 should be approximately 1/5 the signal amplitude at the source of Q201. This is because the SWEEP LENGTH control, R202, and HORIZ GAIN control, R21, form a voltage divider. The total resistance of the voltage divider is 25 kΩ. Since the HORIZ GAIN control, R21, contains 1/5 of the total resistance in the voltage divider, it will develop 1/5 of the total signal.

EXAM

Complete Exam 9575-1 and return the exam card to the Instruction Department.

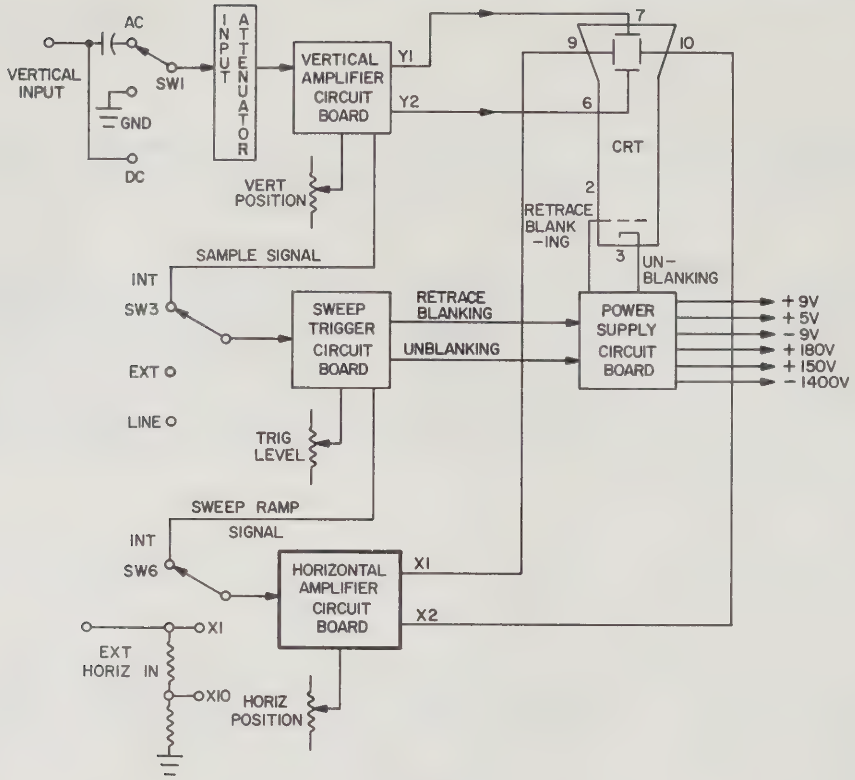


FIGURE 2-1

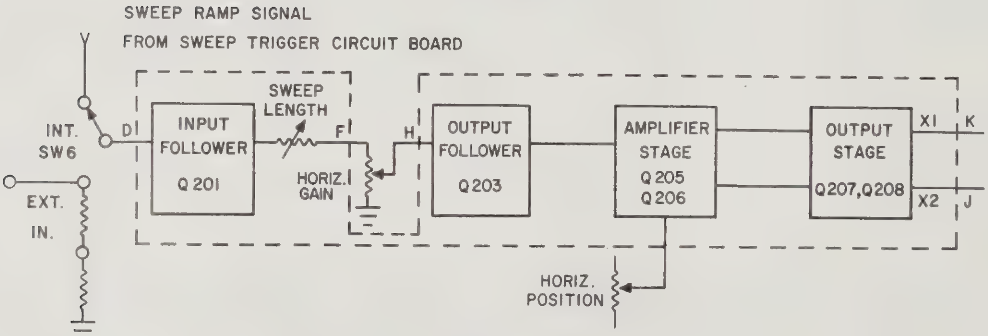


FIGURE 2-2

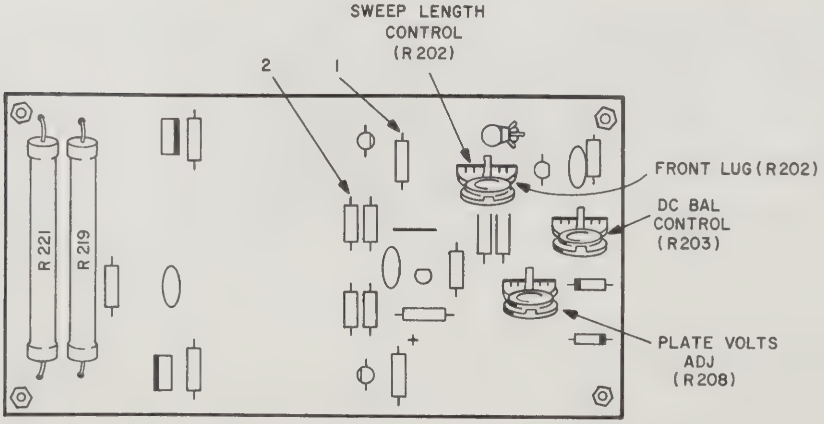


FIGURE 2-4

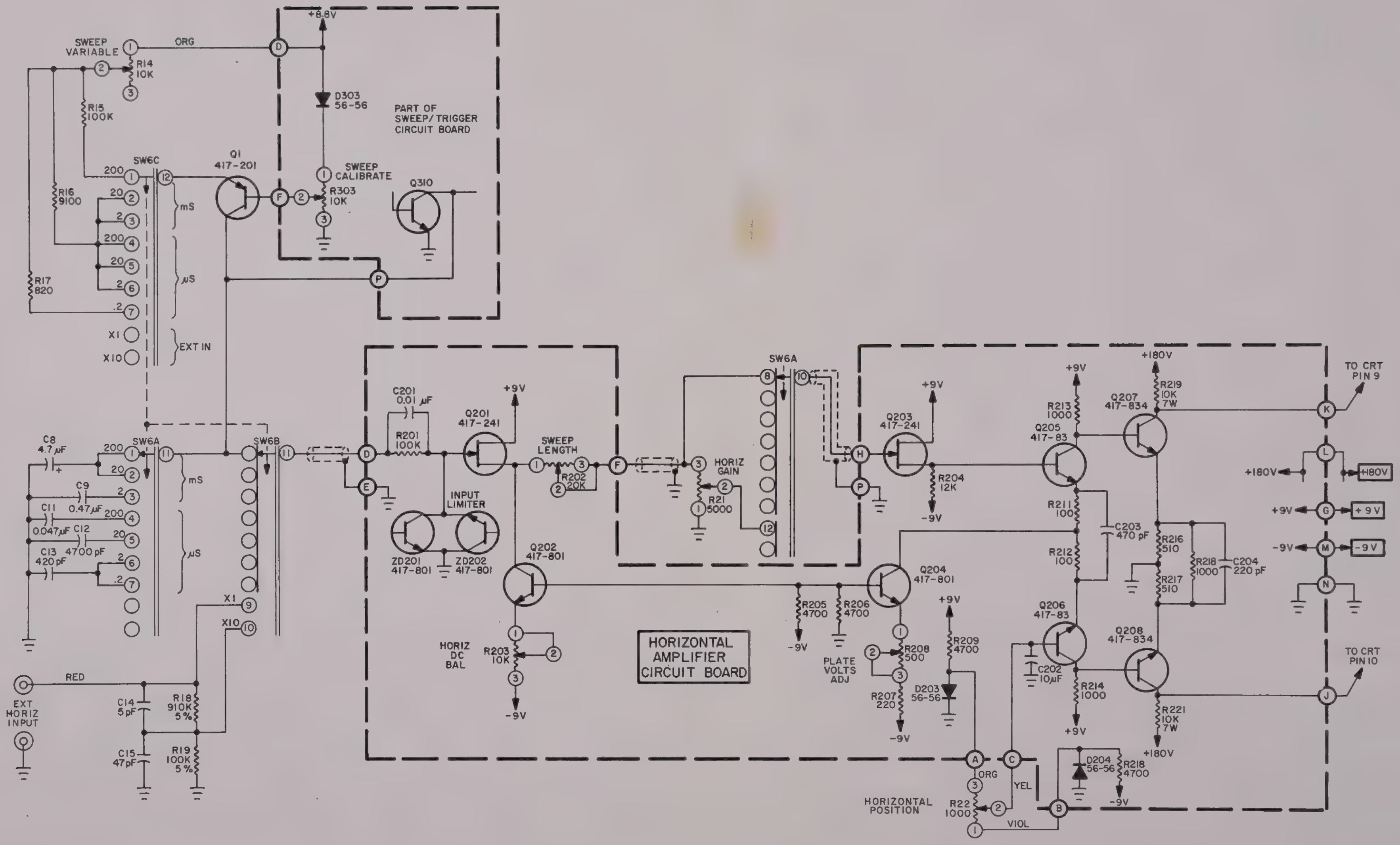

SWEEP VARIABLE
R14 10K
ORG
+8.8V
D303 56-56
PART OF SWEEP/TRIGGER CIRCUIT BOARD
R15 100K
R16 9100
R17 820
SW6C
200
20
2
mS
μS
.2
X1
X10
EXT IN
Q1 417-201
SWEEP CALIBRATE
R303 10K
Q310
C8 4.7μF
C9 0.47μF
C11 0.047μF
C12 4700 pF
C13 420 pF
SW6A
SW6B
EXT HORIZ INPUT
RED
C14 5 pF
C15 47 pF
R18 910K 5%
R19 100K 5%
C201 0.01 μF
R201 100K
Q201 417-241
+9V
SWEEP LENGTH
R202 20K
INPUT LIMITER
ZD201 417-801
ZD202 417-801
Q202 417-801
HORIZ DC BAL
R203 10K
-9V
HORIZONTAL AMPLIFIER CIRCUIT BOARD
HORIZ GAIN
R21 5000
Q203 417-241
R204 12K
Q204 417-801
R205 4700
R206 4700
PLATE VOLTS ADJ
R208 500
R207 220
R209 4700
D203 56-56
Q205 417-83
Q206 417-83
R213 1000
R211 100
R212 100
C203 470 pF
C202 10μF
R214 1000
+180V
Q207 417-834
Q208 417-834
R219 10K 7W
R221 10K 7W
R216 510
R217 510
R218 1000
C204 220 pF
D204 56-56
R218 4700
TO CRT PIN 9
TO CRT PIN 10
+180V
+9V
-9V
HORIZONTAL POSITION
R22 1000
ORG
YEL
VIOL

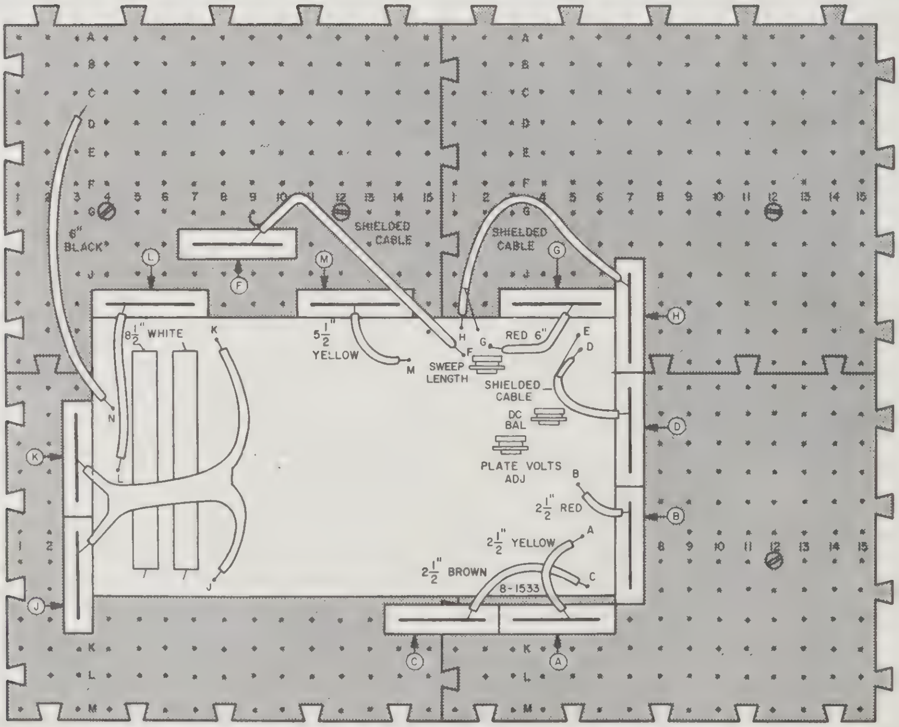
FIGURE 2-3

Figure 2-3 is a foldout and is inserted in the back of this Manual.

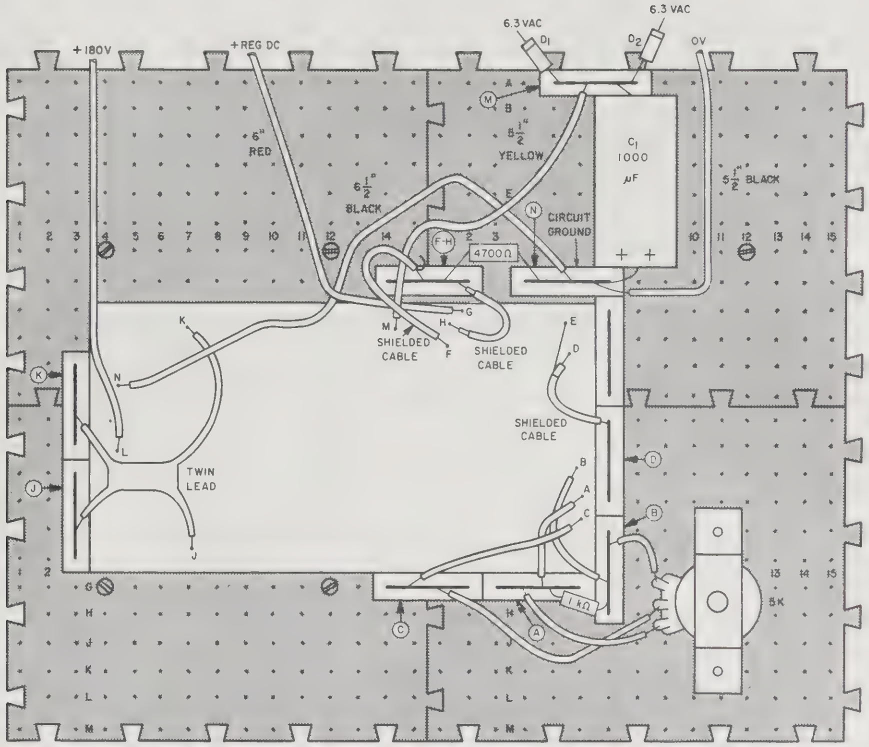
FIGURE 2-3

QUANTITY	COLOR	LENGTH	POINT
1	Brown	2-1/2"	C
1	Yellow	2-1/2"	A
1	Red	2-1/2"	B
1	Red	6"	G
1	Yellow	5-1/2"	M
1	Black	6"	N
1	White	8-1/4"	L

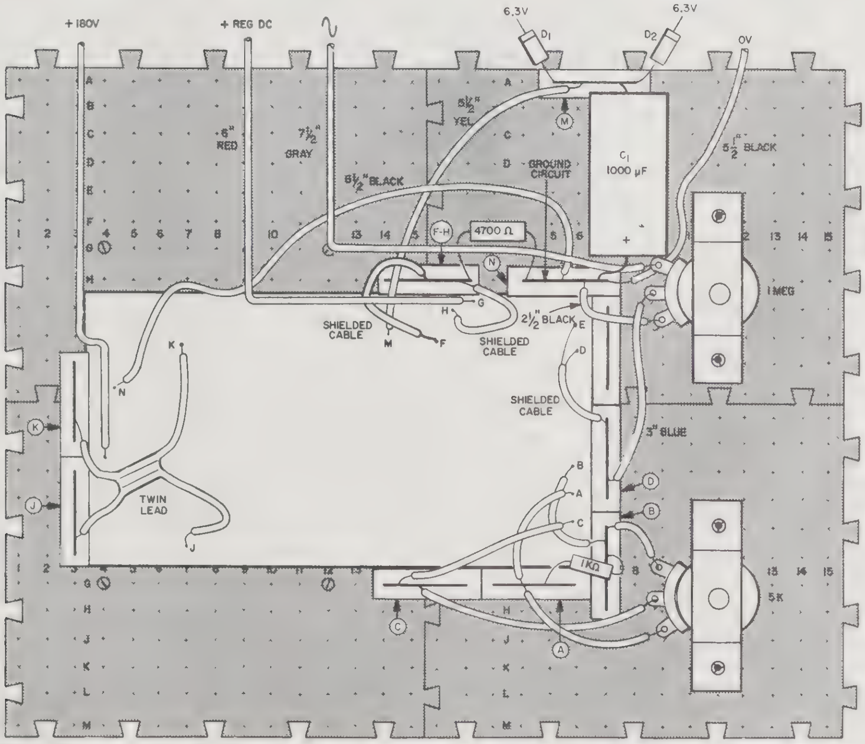
TABLE 2-1



LAYOUT 2-1



LAYOUT 2-2



LAYOUT 2-3

POINT	RESISTANCE	YOUR READING
C	1.75 kΩ	
A	148Ω	
B	14.4 kΩ	
D	780 kΩ	
H	12.4 kΩ	
G	1.41 kΩ	
M	9.2 kΩ	
F	83 kΩ	
K	∞	
J	∞	
L	∞	

TABLE 2-2

All resistances measured with respect to ground.

QUESTIONS

IMPORTANT — These instructions **MUST** be accurately followed to avoid loss, or errors in grading.

Indicate your answer on this sheet by filling in the box for the most correct answer to each question.

When all questions have been answered, place the answer card in the proper position to line up the boxes on the card with the boxes on the sheet.

Next, copy the complete lesson code into the space provided on the card, and fill in the answer boxes to correspond with those previously filled in on this sheet.

Before mailing, be certain your correct student number, name and address appear on the card.

LESSON CODE
9575-1A

1. Vertical DC Balance control R103 is adjusted for zero volts at the source of (Refer to Figure 1-3)

A ☐
B ☒
C ☐
D ☐

(A) Q102 with a signal applied. (B) Q102 with no signal applied. (C) Q101 with a signal applied. (D) Q101 with no signal applied.

2. An input signal to the scope will not cause vertical deflection of the CRT trace. However, R8 will cause the trace to move up and down. Which of the following is a possible cause of this problem? (Refer to Figure 1-3)

A ☐
B ☐
C ☑
D ☐

~~(A) C101 open.~~ (B) ZD102 open. (C) Q101 open. (~~D) C103 shorted~~.

3. There is no horizontal deflection when SW6 is switched to the 200 μS position. However, there is normal deflection in all other positions of SW6. Which of the following could cause this problem? (Refer to Figure 2-3)

A ☒
B ☐
C ☐
D ☐

(A) C11 shorted. (B) R16 open. (C) C9 shorted. (D) R303 open.

4. If the signal on the base of Q105 were such that Q105's collector current increases, the collector current of Q106 will (Refer to Figure 1-3)

A ☒
B ☒
C ☐
D ☐

(A) increase. (B) decrease. (C) double. (D) remain the same.

5. There is no horizontal deflection when SW6 is in the ×1 or ×10 position. Sweep deflection is normal in all other positions of SW6. Which of the following is a possible cause of this trouble? (Refer to Figure 2-3)

A ☐
B ☐
C ☒
D ☐

(A) Q201 open. (B) Q201 shorted. (C) R21 lug 3 open. (D) R21 lug 1 open.

6.
A ☐
B ☐
C ☐
D ☐

THIS EXAM CONTAINS ONLY FIVE QUESTIONS

7.
A ☐
B ☐
C ☐
D ☐

8.
A ☐
B ☐
C ☐
D ☐

9.
A ☐
B ☐
C ☐
D ☐

10.
A ☐
B ☐
C ☐
D ☐

PROJECT 3

SWEEP/TRIGGER CIRCUIT BOARD

PARTS NEEDED

IOD-4540 Power Supply Circuit Board Assembly Parts

2 - Silicon Diodes

1 - 1000 μF, 50V DC Electrolytic Capacitor

1 - 5 kΩ Potentiometer

16 - Modular Connectors

1 - 10Ω,1W Resistor

1 - 20Ω,1/2W Resistor

2 - 10 MFD,50V Electrolytic Capacitor

1 - 100 kΩ,1/2W Resistor

1 - PNP Transistor

DISCUSSION

In this project you will assemble and test the SWEEP/TRIGGER CIRCUIT BOARD of your oscilloscope. As shown in Figure 3-1, when the INT/EXT/LINE switch, SW3, is in the INT (internal) position, the SWEEP/TRIGGER CIRCUIT BOARD receives a sample of the signal from the Vertical Amplifier Circuit Board.

When SW3 is in the EXT (external) position, an external signal is applied to the SWEEP/TRIGGER CIRCUIT BOARD. In the LINE position of SW3, a 1 volt p-p sample of the line voltage (60 Hz) is applied to the input of the circuit, which triggers the circuitry.

The SWEEP/TRIGGER CIRCUIT BOARD provides three output signals. Two of these signals, the Retrace Blanking and Unblanking signals, are applied to the Power Supply Circuit Board for processing before they are sent to the CRT. The third and most important output is the Sweep Ramp Signal, which is applied to the Horizontal Amplifier Circuit Board. It is used to generate a horizontal sweep signal that is synchronized with the input trigger signal.

For convenience we are dividing the SWEEP/TRIGGER CIRCUIT BOARD into two sections, the first section of which is the Trigger Circuitry.

The block diagram of the TRIGGER circuitry is shown in Figure 3-2. The operation of this circuit board is identical in all positions of SW3, so only the operation in the INT position will be discussed.

The Sample Signal from the Vertical Amplifier Circuit Board is applied to SW3, and coupled to Input Follower Q301. The Input Follower serves primarily as an isolation circuit. The setting of the TRIG (trigger) LEVEL control determines the signal amplitude necessary to obtain the desired trigger signal. The output signal from Q301 is coupled to the differential Trigger Amplifier, Q304 and Q305, for amplification. Further amplification takes place in the differential Output Stage, Q306 and Q307. SLOPE switch SW8 allows you to select a trigger signal of the proper polarity for application to the SWEEP circuitry.

Figure 3-3 is the block diagram of the SWEEP circuitry section of the scope. For the moment, we'll ignore the Electronic Switch block (IC302) and the Recurrent Switch Gate block (IC301A). With SW5 in the NORM position, as shown, both of these blocks are non-functional and do not affect the operation of the scope sweep circuitry. We will explain their operation later. The same applies to the Unblanking Pulse Amplifier block (Q308, Q309) and the Anti-Latchup Switch block (IC301B). These are auxiliary circuits that will be explained later.

The trigger pulse, selected by SW8, is applied to the Input Shaper IC301C. The negative output pulse from the Input Shaper is applied to the Ramp/Blanking Pulse Generator, IC303, which is a bistable multivibrator.

The output signal from the Ramp/Blanking Pulse Generator is a positive polarity pulse that is applied to the input of Inverter IC301D. After the signal has been inverted to a negative polarity signal, it is applied to Ramp Sweep Switch Q310. As a result, Q301 is cutoff, allowing the Sweep Ramp Signal to be generated as described in Project 2.

As the Sweep Ramp signal is being generated, a sample of this signal is applied to the Ramp Amplifiers, Q311 and Q312, which provide current gain and isolate the ramp sweep generating circuits from IC304. When the positive-going sawtooth portion of the Ramp Sweep Signal reaches the required level, the Retrace Multivibrator changes states. Since IC304 is a monostable multivibrator, it will remain in its unstable state for a predetermined period of time, then switch back to its stable state. The method by which this time is determined will be discussed later. The negative polarity output pulse from IC304 is then fed back to the Ramp Blanking pulse generator, IC303.

The negative polarity feedback pulse to IC303 causes this bistable multivibrator to switch states once again, producing a negative polarity pulse at its output. This pulse is inverted by IC301-D and applied as a positive polarity pulse to the Ramp Sweep Switch, Q310, causing Q310 to saturate and the Ramp Sweep Signal to be shorted to ground. The entire ramp generating circuitry then remains in this state until another trigger pulse from IC301-C causes the action to repeat.

To summarize the circuit operation: a positive pulse at the input to IC301-C produces a negative pulse at the input to IC303. The output of IC303 goes positive, causing the output of IC301-D to go negative. This turns off Q310 and allows the Ramp Sweep signal to be formed at the output of Q310. (This Ramp Sweep signal is amplified by the circuitry on the Horizontal Amplifier Circuit Board to produce horizontal deflection of the CRT beam.) Then the Ramp Sweep signal is applied through Q311 and Q312 to the Retrace Multivibrator, IC304. When it reaches a certain amplitude it triggers IC304. The output of IC304 is a negative polarity pulse that is fed back to IC303, causing the output of IC303 to go negative and the output of IC301-D to go positive. This turns on Q310, the Ramp Sweep signal is shorted to ground, and the CRT beam retraces. The circuitry remains in this condition until another trigger pulse is applied to the input of IC301-C.

You will notice that the Anti-Latchup Switch, IC301B, also receives the same input signal as the Retrace Multivibrator. The Anti-Latchup circuit is a safety circuit that performs the same functions as the Retrace Multivibrator. However, the Anti-Latchup Switch is only activated if the Retrace Multivibrator does not function properly. The malfunctioning Retrace Multivibrator would allow the output of the Ramp Amplifiers to increase above a predetermined level. The increase in signal level above the predetermined level triggers the Anti-Latchup Switch, which in turn switches the Ramp/Blanking Pulse Generator and turns off the Sweep Ramp Signal.

Again referring to Figure 3-3, when SW5 is set to the AUTO position, the circuitry will function either as a free-running oscillator or as a triggered oscillator depending upon the absence or presence of a trigger signal. With no trigger signal applied, the Electronic Switch, IC302, allows the Recurrent Switch Gate, IC301A, to provide the proper feedback of IC303, causing the sweep circuitry to be recurrent, producing a sawtooth signal at the output of Q310, and a horizontal trace on the face of the CRT.

When a trigger signal is obtained from the Input Shaper, IC301-C, it causes IC302 to turn off the Recurrent Switch Gate, IC301A. In effect, IC301A is removed from the circuit and there is no feedback to cause a recurrent sweep signal. Now, the trigger signal that is applied to IC303 produces a triggered sweep signal in the same manner as described when SW5 was set to the NORM position.

In addition to producing the sweep signal, the circuitry of Figure 3-3 produces two other signals from the output of IC303. One of the outputs from the Ramp/ Blanking Pulse Generator is applied to the Unblanking Amplifier, Q308 and Q309. The output signal of the Unblanking Amplifier is the Unblanking Signal that is sent to the Power Supply Circuit Board, where it is processed and coupled to the CRT. The processed unblanking signal will be used to unblank the CRT during sweep time.

The other output of the Ramp/Blanking Pulse Generator is the Retrace Blanking signal that leaves the SWEEP/TRIGGER CIRCUIT BOARD without amplification. The Retrace Blanking Signal is also applied to the Power Supply Circuit Board and processed. After processing, the Retrace Blanking signal blanks the CRT during retrace time.

In the following discussion we will examine the circuit operation of the SWEEP/ TRIGGER CIRCUIT BOARD, as shown in Figure 3-4. In the discussion we will assume that all switches are as shown in Figure 3-4. The Sample Signal from the Vertical Amplifier Circuit Board is applied through the INT/EXT/LINE switch, SW3, capacitor C6, AC/DC/TV switch, SW4, and R302 to the gate of Q301. R302, ZD301 and ZD302 limit Q301's input signal to 18V p-p.

With the TRIGGER LEVEL control, R13, in the center of rotation, the LEVEL SET control, R304, is adjusted for zero volts at the source of input Follower Q301. The TRIGGER LEVEL control is located in the base circuit, while the LEVEL SET control is located in the emitter circuit of Constant Current Source Q302.

The output signal from Q301 is direct-coupled to the base of Q304. Q304 and Q305 comprise the differential Trigger Amplifier. Q303, in the emitter circuit of Q304 and Q305, serves as a constant current source for the Trigger Amplifier. The amplified output signal from the Trigger Amplifier is also directed-coupled to the differential Output Stage Q306, Q307 for additional amplification.

The circuitry of the Input Preshaper, IC301C, requires a positive pulse to trigger it. To satisfy this requirement, the SLOPE switch, SW8, is in the circuitry. This is necessary because the input to the Vertical Amplifier Circuit Board may be of either polarity. Therefore, SW8 is necessary so that a positive pulse can always be obtained. A negative signal at the input of Q101 (not shown in Figure 3-4) will cause a positive signal to be present at lug 1 of SW8, and a negative signal at lug 3. In order to apply a positive pulse to IC301C, SW8 is switched to the negative (-) position.

To start the explanation of the sweep circuitry, let's first assume that there are no trigger pulses applied and SW5 is in the NORM position. Under these conditions, all inputs to IC303 (pins 2, 12 and 13) are high, causing the output at pin 8 to be low. This causes the output at pin 11 of IC301-D and the input to the base of Q310 to be high, the collector of Q310 to be grounded, and the Sweep Ramp signal is zero. This zero signal is coupled through Q311 and Q312 to input pin 5 of IC304, causing this monostable multivibrator to remain in its stable state. Thus, all of the circuitry is at rest, no sweep signal is generated, and there is no trace on the face of the CRT.

When a trigger signal is present, a negative polarity pulse is obtained from pin 8 of IC301-C and applied to pin 12 of IC303. Since IC303 is a bistable multivibrator, the pulse at pin 8 causes it to change states so that pin 8 goes high, the output at pin 11 of IC301-D goes low, the base of Q310 goes low, and Q310 is cutoff. This allows the ramp sweep signal to be formed at the Q310 collector. The signal is amplified by Q311 and Q312, then applied to the pin 5 input of IC304. When the ramp signal reaches a predetermined amplitude (about 3.5 volt p-p), IC304 is triggered into its unstable state and produces a negative polarity output pulse at pin 1. The width of the output pulse from IC304 is determined by the value of the capacitor (C16 through C22) selected by SW6B FRONT. This pulse is coupled through D308 to pin 2 of IC303, causing pin 8 of IC303 to go low. This pulse is inverted by IC301D, and applied as a positive pulse to the Ramp Sweep Switch, Q310. Q310 then saturates, shorting the Ramp Sweep signal to ground, causing retrace. The circuitry remains in this condition until the next input trigger signal causes the cycle to repeat. As a result, a horizontal trace is seen on the face of the CRT that is synchronized by the input trigger signal.

When SW5 is set to the AUTO position, the circuitry functions either as a free-running oscillator or as a triggered oscillator, depending upon the absence or presence of a trigger pulse at pin 9 of IC301C. When no trigger signal is present, the high voltage level at pin 6 of IC302 allows IC301A to provide the proper feedback to pin 13 of IC303. This causes the sweep circuitry to be recurrent, a sawtooth signal is produced at the output of Q310, and a trace appears on the face of the CRT.

When a trigger signal is obtained from pin 8 of IC301C, it causes the voltage at pin 6 of IC302 to go low. This low turns off the Recurrent Switch Gate, IC301A. The result of this action is that IC301A is effectively removed from the circuit, and no feedback is applied to pin 13 of IC303. Therefore, a recurrent Sweep Ramp Signal will not be generated. Instead, the trigger signal that is applied to pin 12 of IC303 produces a triggered Sweep Ramp Signal in the same manner as described when SW5 is in the NORM position.

The main purpose of the SWEEP circuitry is to produce the sweep signal. However, the Ramp/Blanking Pulse Generator output signals perform additional functions. During trace time, the voltage level at pin 8 of IC303 is high. A sample of this voltage is applied through R319 to the Unblanking Amplifiers, Q308 and Q309. The signal is amplified and inverted by the Unblanking Amplifiers. The amplified signal is coupled through R324 to point G, and leaves the circuit board.

During Retrace time, the positive-going change at pin 6 of IC303 is used to blank the CRT. This signal leaves the Sweep/Trigger Circuit Board at point R.

PROCEDURE

BUILDING THE SWEEP/TRIGGER CIRCUIT BOARD

1. The components for the assembly of the SWEEP/TRIGGER CIRCUIT BOARD are included in shipment WBS-2.

2. Refer to the Assembly and Operation Manual which provides step-by-step instructions for building the circuit board.

3. The list of components required for the assembly of the Sweep Trigger Circuit Board is on pages 31 through 33 of the assembly manual. Open the package that contains components for the Sweep/Trigger Circuit Board. Check the parts you received in shipment WBS-2 against the parts list on pages 31 through 33 to ensure that you received all of the required parts. If any part is missing or defective, follow the instructions in the assembly manual to obtain a replacement part.

4. Follow the assembly procedures given on pages 34 through 41 of the Assembly and Operation Manual. Be sure your soldering iron is clean and properly tinned. Take your time and be sure that all components are properly installed and all solder connections are properly made. The Sweep/Trigger Circuit Board has some connections that are rather close. So be careful to avoid solder bridges across foil conductors.

5. After you have completed the assembly of the Sweep/Trigger Circuit Board, visually inspect the board to ensure that all connections have been properly made and soldered, and proceed with the following steps in this project.

TEST NO. 1

PRELIMINARY RESISTANCE CHECKS

1. In this procedure you will check your wiring and installation of components

on the board before making voltage measurements. If a mistake was made in the installation of components, or if there is a defective component, damage could result when the operating voltages are applied. For this reason, it is a good idea to check the dc resistance of circuits on the board before applying power to the board. This will help you to locate any possible errors or defects and minimize the chance that operating voltages may damage components on the board.

PROCEDURE

1. Begin by preparing the appropriate wire lengths shown in Table 3-1. To prepare the wires, cut them to the correct lengths and then strip 1/4" of insulation from one end and 1/2" of insulation from the other. After the wires are prepared, tack solder the 1/4" end into the PC board at the points indicated in Table 3-1. These wires will be removed later on.

2. Arrange the modular connectors and install the PC board as shown in Layout 3-1. NOTE: Be sure to position the board with the part number at the top center as shown. It may be necessary to tack an extra piece of bare wire to the end of the shield cable to ensure good contact in the modular connector.

3. Insert a wire in each modular connector. Be sure the wire from each lettered point is inserted in the appropriately lettered modular connector. NOTE: The black wire coming from point T should not be connected to a modular connector.

4. Clip the black lead of your DMM to the black wire connected at point T on the PC board.

5. Set all variable controls to their center of rotation.

6. Measure the resistance at all the lettered points indicated in Table 3-2. These measurements should be made at the appropriate modular connectors as indicated in Layout 3-1. All resistances should be within 20% of those listed in Table 3-2.

If the resistance at any point varies by more than ±20% of that shown in Table 3-2, look for an error in assembly.

After all resistances have been checked and found to be within tolerance, remove the DMM clip lead from the wire at point T, but leave the wire connected to this point. Then continue with the following steps in this manual.

ANALYSIS: TEST NO. 1

1. If C305 shorted, what would be the resistance reading at point L?

2. If Q310 shorted, what resistance would be measured at point P?

TEST NO. 2

PRELIMINARY VOLTAGE CHECKS

PROCEDURE

1. Construct circuit Layout 3-2.

2. Be sure the 10Ω and 20Ω resistances are installed correctly, as shown in Layout 3-2.

3. Be sure a black wire is connected between REG DC (-) terminal and 0 VAC terminal.

4. DO NOT connect the output of -9V power supply to the wire coming from K at this time.

5. DO NOT connect the output of the REG DC (+) power supply to the wire coming from L at this time.

6. DO NOT connect the brown wire coming from point H on the circuit board to the modular connector H at this time. Instead, position the free end so that it is not touching any electrical point.

7. Turn on the design console and check the output of the -9V power supply to make sure that the voltage and polarity is correct. NOTE: The voltage will probably measure slightly high when unloaded.

8. Adjust the output of the REG DC supply for a +5 volt reading at modular connector H.

9. Turn off the design console and connect the yellow wire coming from point K on the PC board to the output of the -9V power supply.

10. Connect the red wire coming from point L on the PC board to the REG DC (+) terminal.

11. Connect the brown wire coming from point H on the PC board to modular connector H.

12. Turn on the design console and recheck the voltages. If necessary, readjust the output of the REG DC supply for +9V.

13. Prepare the 5 kΩ pot as shown in Figure 3-5.

14. Double check your work. Make sure that all wiring is connected as shown in Layout 3-2. Be certain that the 5 kΩ pot is connected properly.

15. Connect the black DMM lead to the REG DC (-) terminal which will serve as circuit ground.

16. Measure the voltages of all the lettered points indicated in Table 3-3. All voltages should be within 20% of those listed in Table 3-3.

17. Turn off the design console.

ANALYSIS: TEST NO. 2

1. Why are the voltages at W and V different?

TEST NO. 3

PRELIMINARY CALIBRATION

In this test you will perform a preliminary calibration procedure on the circuit board. However, it will be necessary to recalibrate the board later.

PROCEDURE

1. Construct circuit Layout 3-3.

2. Install the 5 kΩ pot on the design console as shown in Layout 3-3.

3. Set the 5 kΩ pot to the center of rotation.

4. Install a 3-1/2" black wire between the REG DC (-) terminal and modular connector B.

5. Turn on the design console.

6. Measure the REG DC supply and readjust for +9V, if necessary.

7. Set the voltmeter to measure 1.5 volts DC. Touch the meter probe to the S (source) lead of transistor Q301 on the sweep-trigger circuit board (see Figure 3-6) and turn the LEVEL SET control to obtain a zero volt reading.

8. Alternately measure the voltage at modular connectors W and V. Adjust the 5 kΩ pot until the voltages are approximately equal.

9. Turn off the design console.

ANALYSIS: TEST NO. 3

1. If the dc voltage at the source of Q301 were .3V, would the voltages at points W and V be equal? Explain your answer.

TEST NO. 4

AC SIGNAL TRACING

In this test we will be applying a signal to the input of the board and tracing the signal through the stages. The test signal source will be the output signal from the design console sinewave generator. The Sweep/Trigger Circuit Board normally processes a sample of the vertical input signal. However, the circuit board is capable of processing an external sinewave. For this reason, a sinewave input will provide a reliable test of circuit board operation. Be sure that Test No. 3 has been completed before starting the test.

PROCEDURE

1. Prepare the MΩ pot as shown in Figure 3-7.

2. Construct circuit Layout 3-4. Refer to Figure 3-8 for the basing diagram of the transistor. The external PNP transistor and its associated components will function as a ramp sweep generator for this test.

3. Be sure there is a wire connected from REG DC (-) binding post to the 0 VAC binding post.

4. Be sure the 5 kΩ and 1 MΩ pots are installed properly. Also, check to be sure that all wires are installed in the proper modular connectors.

5. Double check the polarity of the capacitors to be sure they are installed properly.

6. Check the transistor to be sure it is installed properly.

7. Set the design console frequency adjustment control fully counterclockwise.

8. Turn on the design console.

9. Adjust the REG DC output for a +9 volts.

10. Set your DMM to measure 4.0 VAC.

11. Connect the meter ground to circuit ground (-REG DC).

12. Connect the red DMM lead to point B and adjust the 1 MΩ pot for a 4.0 VAC reading. NOTE: When making signal voltage measurements in the following steps, allow the DMM reading to settle, when necessary.

13. Measure and record the signal voltage at the source of Q301 by touching the red DMM probe to point 1. (Refer to Figure 3-9.) ____________ volts.

14. Determine the gain of Q301. ____________

15. Set your DMM to measure .50 VAC.

16. Adjust the 1 MΩ pot fully counterclockwise.

17. Connect the red DMM lead to point B and adjust the 1 MΩ pot for a .50 VAC.

18. Measure and record the signal voltage at the base of Q304 by touching the red DMM probe to point 1. (Refer to Figure 3-9.) ____________ volts.

19. Measure and record the signal voltage at the collector of Q304 by touching the red DMM probe to point 2. (Refer to Figure 3-9.) ____________ volts.

20. Determine the gain of Q304. ____________

21. Measure and record the signal voltage at the emitter of Q304 by touching the red DMM lead to point W.

22. Determine the gain of Q306.

23. With a .50 VAC input, determine the overall gain from the input to the Slope Switch (SW8).

NOTE: In the following steps we will be observing the action of the pulses of the Sweep/Trigger Circuit Board.

24. Observe the action of the Retrace Blanking signal by touching the red DMM lead to point 3. (Refer to Figure 3-9.)

25. Observe the action of the Unblanking signal by touching the red DMM lead to point 4. (Refer to Figure 3-9).

26. Observe the action of the clear pulses of IC303 by touching the red DMM lead to point 5. (Refer to Figure 3-9).

27. Observe the action of the Retrace Multivibrator by touching the red DMM lead to point M. (Refer to Figure 3-9).

28. Set the DMM to measure 1.5 VAC.

29. Connect the red DMM lead to point P.

30. Slowly rotate the SWEEP CAL control in both directions and observe its effect.

31. Turn off the design console.

This completes the test on the SWEEP/TRIGGER circuit board. Remove the printed circuit board from the design console, and remove the temporary wires (see Table 3-1). Disassemble the circuit on the design console and set the board aside until it is called for in the chassis assembly instructions.

ANALYSIS: TEST NO. 4

Assume a .1 μF capacitor is installed between modular connectors M and N. Would the voltage observed at point M fluctuate faster or slower? Why?

2. If the wiper of the TRIGGER LEVEL control is moved toward lug 3, what is the effect on the voltage at point V? Why?

PROJECT 3: ANALYSIS ANSWERS

TEST NO. 1

1. 2.7Ω, because with the capacitor shorted you are measuring across R325.

2. Zero, because the shorted transistor acts as a length of wire between point P and circuit ground.

TEST NO. 2

1. Since the circuit is not balanced, Q306 and Q307 are biased differently. The difference in biasing causes the two transistors to have different conduction levels. Because of the difference in conduction levels, different voltage levels will be present at points W and V.

TEST NO. 3

1, No, because the .3V at the source of Q301 is also applied to the base of Q304, increasing its conduction. As the conduction level of Q304 increases, the conduction level of both Q305 and Q306 decrease. The decrease in conduction level of Q305 causes an increase in conduction of Q307. This is because a higher positive level is being applied to the base of Q307. As the conduction level of Q307 increases, a higher positive level will be present at point V. A lower level will be present at W because the conduction level of Q306 is decreasing.

TEST NO. 4

1. Faster, because a .1 μF capacitor would provide a shorter RC time constant. Therefore, the width of the output pulse from the Retrace Multivibrator will be shorter.

2. Point V will become more positive. As the wiper of the TRIGGER LEVEL control (R13) is moved toward lug 3, Q302 conduction level decreases. As the conduction level of Q302 decreases, the conduction level of Q304 increases. This causes the conduction level of both Q305 and Q306 to decrease. The decrease in conduction level of Q305 causes an increase in conduction of Q307. As the conduction level of Q307 increases, a higher positive level will be present at point V.

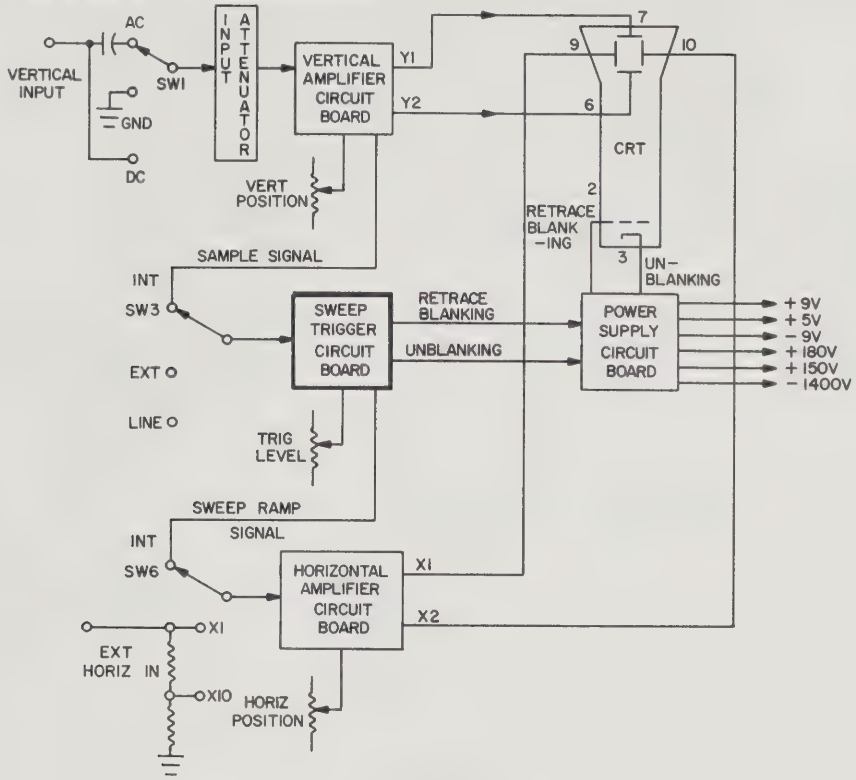


FIGURE 3-1

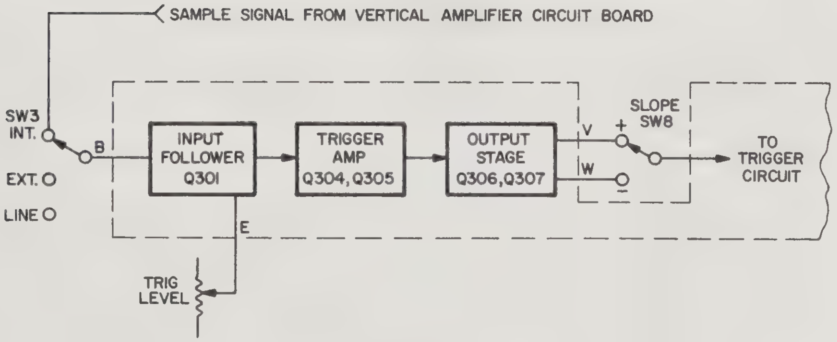


FIGURE 3-2

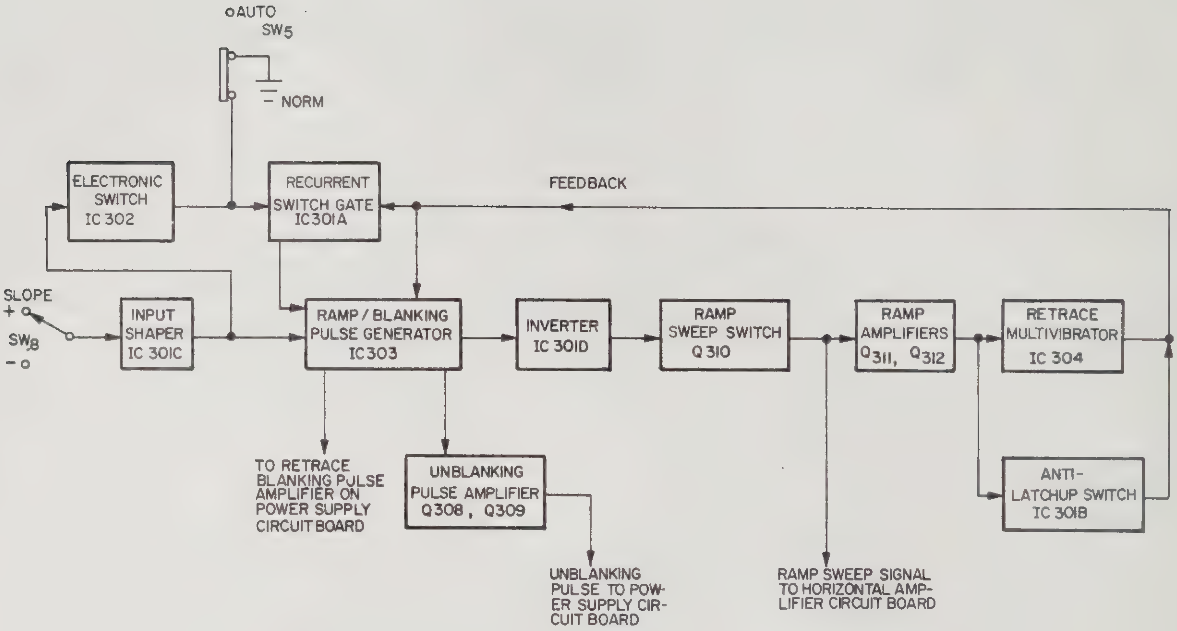

AUTO
SW5
NORM
ELECTRONIC SWITCH IC 302
RECURRENT SWITCH GATE IC301A
FEEDBACK
SLOPE
+
SW8
-
INPUT SHAPER IC 301C
RAMP / BLANKING PULSE GENERATOR IC303
INVERTER IC 301D
RAMP SWEEP SWITCH Q 310
RAMP AMPLIFIERS Q311, Q312
RETRACE MULTIVIBRATOR IC 304
ANTI-LATCHUP SWITCH IC 301B
TO RETRACE BLANKING PULSE AMPLIFIER ON POWER SUPPLY CIRCUIT BOARD
UNBLANKING PULSE AMPLIFIER Q308, Q309
UNBLANKING PULSE TO POWER SUPPLY CIRCUIT BOARD
RAMP SWEEP SIGNAL TO HORIZONTAL AMPLIFIER CIRCUIT BOARD

FIGURE 3-3

QUANTITY	COLOR	LENGTH	POINT
1	Red	6-1/2"	L
1	Yellow	3-1/2"	K
1	Brown	2-1/2"	H

TABLE 3-1

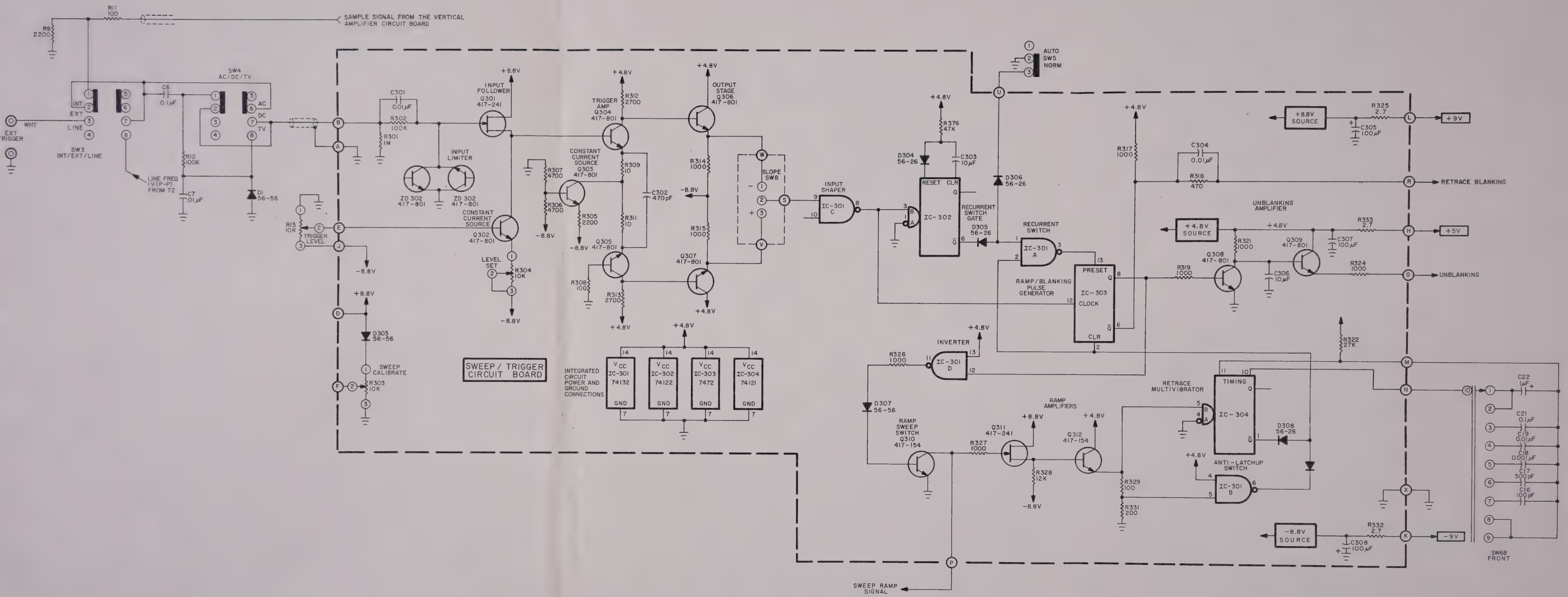

R11 100
R9 2200
SAMPLE SIGNAL FROM THE VERTICAL AMPLIFIER CIRCUIT BOARD
SW4 AC/DC/TV
C6 0.1µF
INT
EXT
LINE
WHT
EXT TRIGGER
SW3 INT/EXT/LINE
AC
DC
TV
R12 100K
C7 .01µF
D1 56-56
LINE FREQ 1V(P-P) FROM T2
C301 0.01µF
R302 100K
R301 1M
INPUT FOLLOWER Q301 417-241
+8.8V
INPUT LIMITER
ZD 302 417-801
ZD 302 417-801
R13 10K
TRIGGER LEVEL
CONSTANT CURRENT SOURCE Q302 417-801
LEVEL SET
R304 10K
-8.8V
+4.8V
TRIGGER AMP Q304 417-801
R312 2700
CONSTANT CURRENT SOURCE Q303 417-801
R307 4700
R306 4700
R305 2200
R309 10
R311 10
C302 470pF
Q305 417-801
R308 100
R313 2700
OUTPUT STAGE Q306 417-801
R314 1000
R315 1000
Q307 417-801
SLOPE SW8
D303 56-56
SWEEP CALIBRATE
R303 10K
SWEEP / TRIGGER CIRCUIT BOARD
INTEGRATED CIRCUIT POWER AND GROUND CONNECTIONS
VCC IC-301 74132 GND
VCC IC-302 74122 GND
VCC IC-303 7472 GND
VCC IC-304 74121 GND
INPUT SHAPER
IC-301 C
R376 47K
D304 56-26
C303 10µF
RESET CLR
IC-302
RECURRENT SWITCH GATE
D305 56-26
AUTO SW5 NORM
D306 56-26
RECURRENT SWITCH
IC-301 A
RAMP/BLANKING PULSE GENERATOR
PRESET
IC-303
CLOCK
CLR
R317 1000
C304 0.01µF
R318 470
RETRACE BLANKING
+8.8V SOURCE
R325 2.7
C305 100µF
+9V
UNBLANKING AMPLIFIER
+4.8V SOURCE
R333 2.7
+5V
R321 1000
Q308 417-801
Q309 417-801
C307 100µF
R324 1000
R319 1000
C306 10µF
UNBLANKING
R322 27K
INVERTER
R326 1000
IC-301 D
D307 56-56
RAMP SWEEP SWITCH Q310 417-154
RAMP AMPLIFIERS
Q311 417-241
R327 1000
Q312 417-154
R328 12K
R329 100
R331 200
RETRACE MULTIVIBRATOR
TIMING
IC-304
D308 56-26
ANTI-LATCHUP SWITCH
IC-301 B
-8.8V SOURCE
R332 2.7
C308 100µF
-9V
C22 1µF
C21 0.1µF
C19 0.01µF
C18 0.001µF
C17 500pF
C16 100pF
SW6B FRONT
SWEEP RAMP SIGNAL

FIGURE 3-4

Figure 3-4 is a foldout and is inserted in the back of this Manual.

FIGURE 3-4

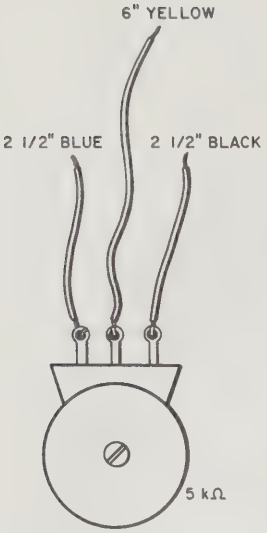


FIGURE 3-5

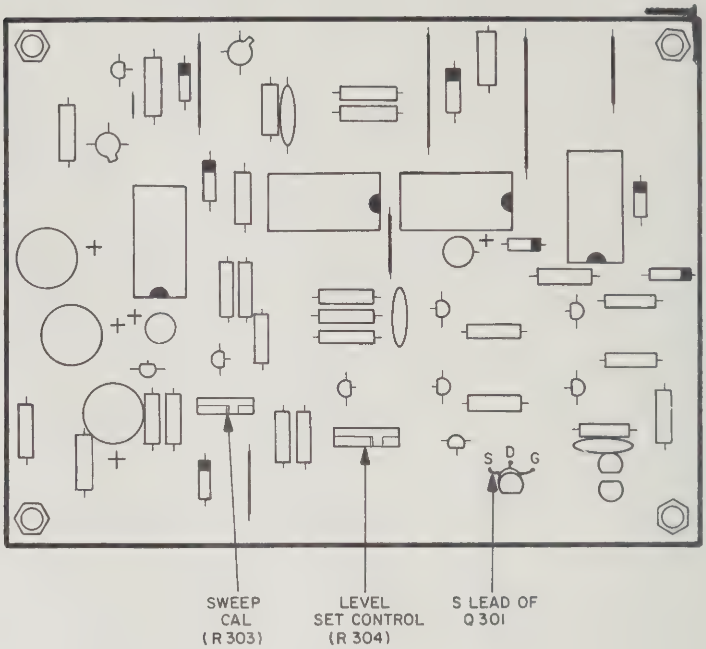


FIGURE 3-6

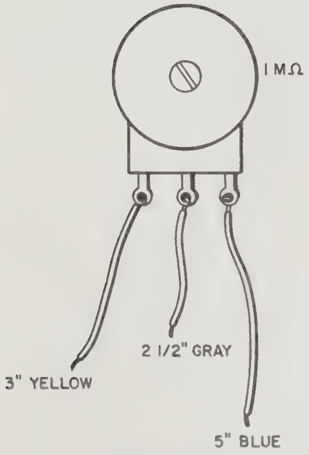


FIGURE 3-7

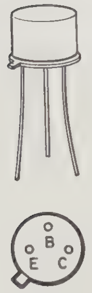


FIGURE 3-8

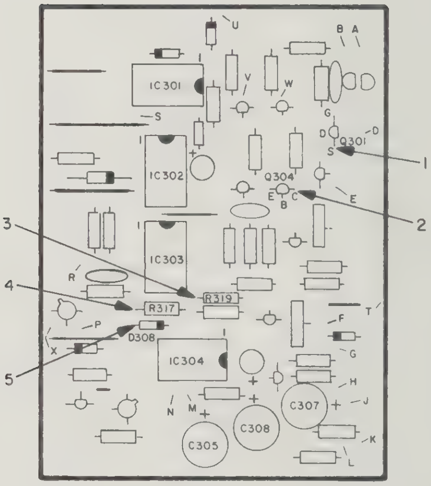


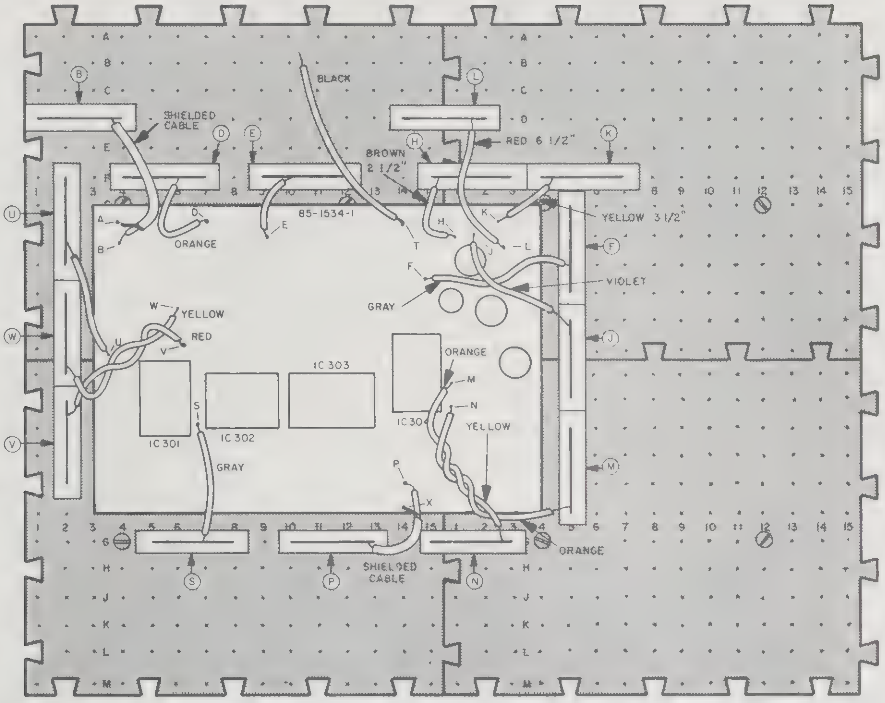
FIGURE 3-9

POINTS	RESISTANCE	YOUR READING
S	∞	
P	13.7 kΩ	
N	1.47 kΩ	
M	184Ω	
J	8.1 kΩ	
F	7.0 kΩ	
K	8.1 kΩ	
H	173Ω	
L	7.6 kΩ	
E	14.0 kΩ	
D	7.5 kΩ	
B	165 kΩ	
U	820 kΩ	
W	9.2 kΩ	
V	9.2 kΩ	

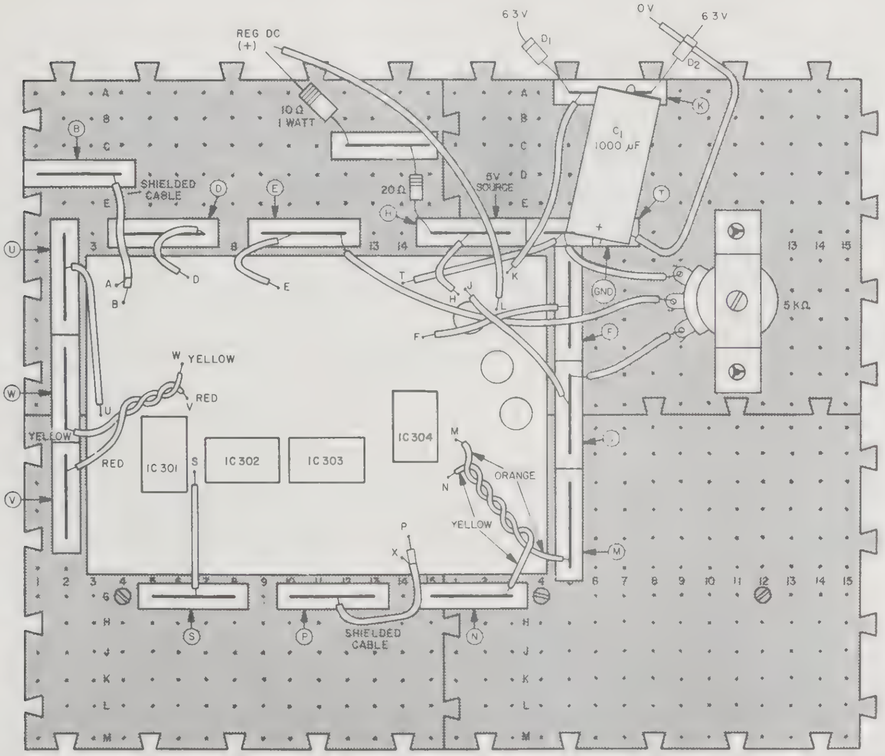
TABLE 3-2

POINTS	VOLTAGE	YOUR READING
S	1.3V	
P	0V	
N	4.6V	
M	.74V	
J	-9.1V	
F	4.6V	
K	-9.2V	
H	5.0V	
E	7.7V	
D	9.0V	
B	0V	
U	1.95V	
W	-.56V	
V	3.7V	

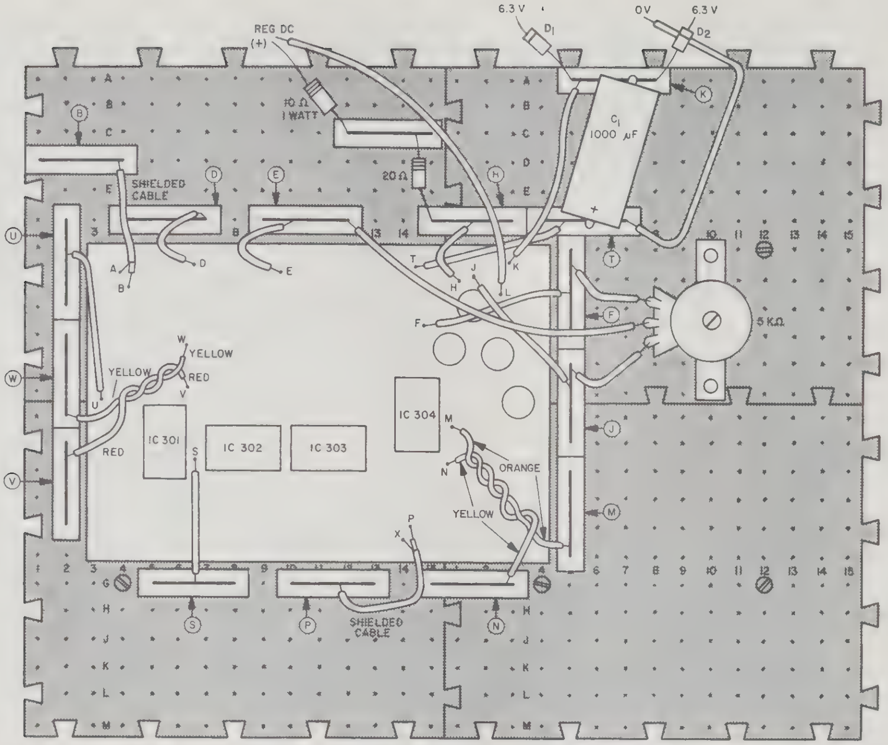
TABLE 3-3



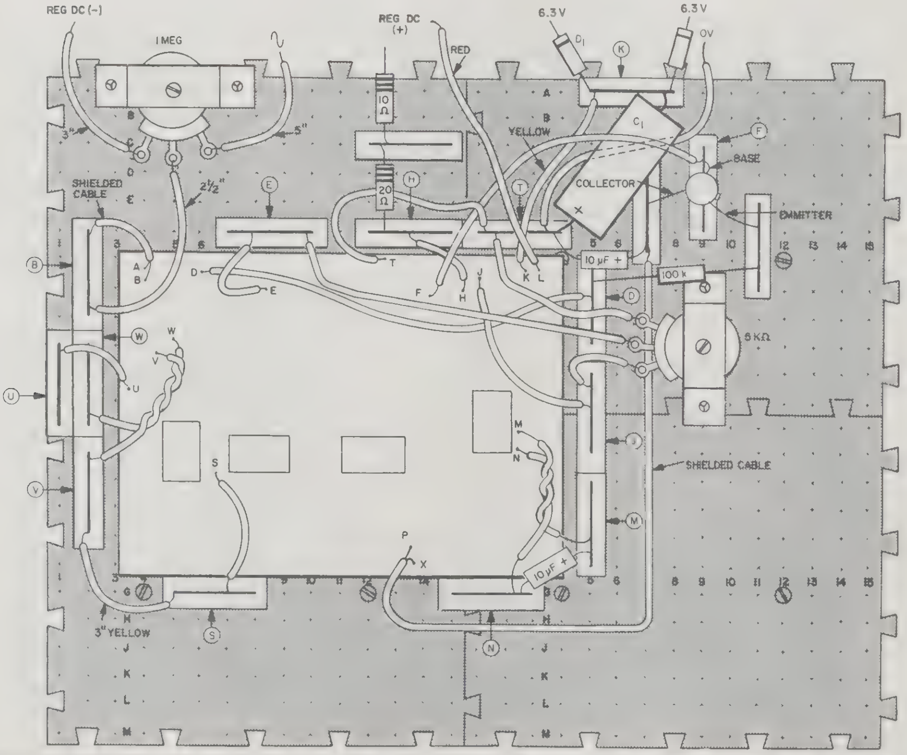
LAYOUT 3-1



LAYOUT 3-2



LAYOUT 3-3



LAYOUT 3-4

PROJECT 4

POWER SUPPLY CIRCUIT BOARD

PARTS NEEDED

IOD-4540 Power Supply Circuit Board Assembly Parts

4 Modular Connectors

DISCUSSION

In this project, you will construct and make resistance tests on the POWER SUPPLY CIRCUIT BOARD of your oscilloscope. As indicated in the block diagram of Figure 4-1, the power supply provides the necessary dc voltages and currents that cause the other circuits to function properly. In addition to providing the necessary operating voltages, the Power Supply Circuit Board also contains most of the circuitry necessary for the blanking and unblanking of the CRT.

The functional block diagram of the Power Supply Circuit Board is shown in Figure 4-2. The figure shows that the circuit board has five basic functions. The Retrace Blanking Circuit receives the Retrace Blanking Signal from the Sweep/Trigger Circuit Board, processes the signal, and applies the processed signal to the control grid of the CRT. The output signal from the Retrace Blanking Circuit blanks the CRT during retrace time.

The Unblanking Circuit unblanks the CRT during sweep time. The Unblanking Circuit receives the Unblanking Signal from the Sweep/Trigger Circuit Board, and after processing the signal, applies it to the CRT cathode.

The High Voltage Supply produces approximately -1400 volts dc for the CRT cathode. This voltage provides the necessary trace brightness when the Unblanking Circuit unblanks the CRT. The -1400 volts is also applied to one side of the CRT filament to prevent cathode-to-filament arcing.

The Low Voltage Supply provides the low voltages that are required for the operation of most of the circuitry in your scope. The three regulated output voltages from the Low Voltage Supply are +9 volts dc, +5 volts dc, and -9V dc.

The Plate Voltage Supply develops +180 volts dc, which is the operating voltage for the Output Stage of the Horizontal Amplifier Circuit Board. The +150 volt dc supply is the operating voltage for the Vertical Amplifier Circuit Board Output Stage.

The schematic diagram of the IOD-4540 Power Supply Circuit Board, the CRT control circuitry and other associated circuits are shown in Figure 4-3. The Retrace Blanking Circuit, which is a CRT control circuit, is located on the Power Supply Circuit Board. The purpose of the Retrace Blanking Circuit, Q401 and associated components, is to apply a negative voltage on the CRT control grid during sweep retrace time. This is initiated by the Retrace Blanking Signal, which is a positive-going signal. The Retrace Blanking Signal causes Q401 to conduct heavily — at or near saturation. This heavy conduction level causes a negative polarity pulse to be present at the collector of Q401. This negative polarity pulse is then coupled through C403 to the control grid of the CRT, causing cutoff of the electron beam current and blanking the retrace on the face of the CRT.

At the end of retrace time, the Retrace Blanking Signal returns to its low level, cutting off Q401. This causes the collector voltage of Q401 to increase toward +180 volts. However, ZD403 prevents Q410's collector voltage from increasing above +68 volts, which is the proper operating voltage for Q401.

The Retrace Blanking Circuit cuts off the CRT beam current during sweep retrace time. However, the Unblanking Circuit controls the intensity of the trace during sweep time. The Unblanking Circuit receives the Unblanking Signal from the Sweep/Trigger Circuit Board. The Unblanking signal, which is a negative-going pulse, is applied to pin 1 of Optical Isolator IC401, and places pin 1 at ground potential.

IC401is an optical isolator which uses light for switching instead of an electrical connection. This circuit provides isolation between the low and high voltage sections of the oscilloscope. Inside the IC there is an LED (light emitting diode) and a phototransistor. When the LED is turned on, light strikes the base region of the phototransistor, turning it on. Conversely, when the LED is turned off, the phototransistor turns off.

When the negative Unblanking Signal is applied to the LED in the Optical Isolator, the LED no longer emits light. Consequently, the phototransistor cuts off. This causes a large resistance to be present from the base to the emitter of Q402, causing Q402 to be forward biased and to conduct heavily. When Q402 is conducting, its internal resistance is low and its collector-to-emitter voltage is low. Since the collector-to-emitter voltage of Q402 is the CRT bias voltage, the CRT bias voltage is low and the CRT is turned on. By varying the INTENSITY control, R28, the conduction through Q402 changes, thereby changing the brightness of the CRT trace.

At the end of sweep time, the Unblanking Signal rises to its positive voltage level. The positive voltage level forward biases the LED in IC401, and the LED emits light. The light from the LED brings the phototransistor into conduction, causing Q402 to cut off. This causes the Q402 collector-to-emitter voltage to be high, which in turn, biases the CRT so that the CRT beam is blanked until the next trace starts.

The High Voltage Supply consists of the high voltage secondary of T1 and a voltage doubler which is comprised of D401, D402, C405, C406, C404, and R408. The dc voltage input to the voltage doubler is approximately 570 volts rms. The High Voltage Supply provides approximately -1400 volts dc for the CRT.

The Low Voltage Power Supply and the Plate Voltage Supply both use bridge rectifiers and RC π filters. T2 has a separate secondary winding for each supply. ZD415, ZD413, and ZD414 regulate the +9 volt, +5 volt, and -9 volt dc supplies respectively. Regulators are not used in the +180 volt and +150 volt dc supplies in the Plate Voltage Supply.

T2 has a secondary winding that provides 1 volt, peak-to-peak, 60 Hz to the INT/EXT/LINE switch, SW3. The voltage from this secondary winding is used to trigger the Sweep/Trigger Circuit Board when SW3 is in the LINE position.

PROCEDURE

Building the Power Supply Circuit Board

1. Refer to the Operation and Assembly Manual which gives the step-by-step construction procedure for building the Power Supply Circuit Board.

2. The components used on the Power Supply Circuit Board are listed and shown on pages 43 through 45 of the Assembly and Operation Manual. Check the parts that you have received against this parts list.

3. Follow the construction procedures given on pages 46 to 52 in the assembly manual.

4. When you have completed the Power Supply Circuit Board and are sure that your assembly is correct, continue with the following steps in this project.

Since it is not practical to apply voltages to the Power Supply Circuit Board, the test will be limited to making resistance measurements. Do not plug in the Design Console for these tests.

TEST NO. 1

1. Prepare a 4" length of black hookup wire by stripping 1/4" of insulation from one end and 1/2" of insulation from the other end.

2. Insert the end of the wire that has 1/4" of insulation stripped from it into the hole at point DD of the Power Supply Circuit Board. Insert the wire from the component side of the board, and tack solder the wire to the foil.

3. Install 4 modular connectors on your design console as shown in Layout 4-1. It will not be necessary to connect any wires to these connectors.

4. Place the Power Supply Circuit Board, foil side up, on the design console as shown in the layout.

5. Clip your black DMM test lead to the 4" black wire soldered to point DD.

6. Measure the resistance of all points listed in Table 4-1 with respect to point DD, which is circuit ground. Refer to Layout 4-1 to locate the points listed in the table. All resistances should be within ±20% of those listed in Table 4-1.

ANALYSIS: TEST NO. 1

1. Why are so many of the readings INFINITE?

TEST NO. 2

1. Reverse the red and black meter leads at the input to the DMM.

2. Measure the resistance of all points listed in Table 4-2 with respect to point DD. Refer to Layout 4-1 to locate the points. All resistances should be within ±20% of those listed in the table.

ANALYSIS: TEST NO. 2

1. Why did the resistance at so many of the points change from infinity to a relatively low reading?

ANALYSIS ANSWERS: PROJECT 4

TEST NO. 1

1. When the ohmmeter applies voltage to the circuitry on the Power Supply Circuit Board, it reverse biases the diodes on the board.

TEST NO. 2

1. Now, the voltage from the ohmmeter has the opposite polarity, the Power Supply diodes are forward biased, and they conduct.

This completes the tests on the Power Supply Circuit Board. Remove the 4" black wire from the hole at point DD. Set the circuit board aside until it is called for in the chassis assembly instructions. Now, proceed to Project 5.

EXAM

Complete Exam 9575-2 and return the exam card to the Instruction Department.

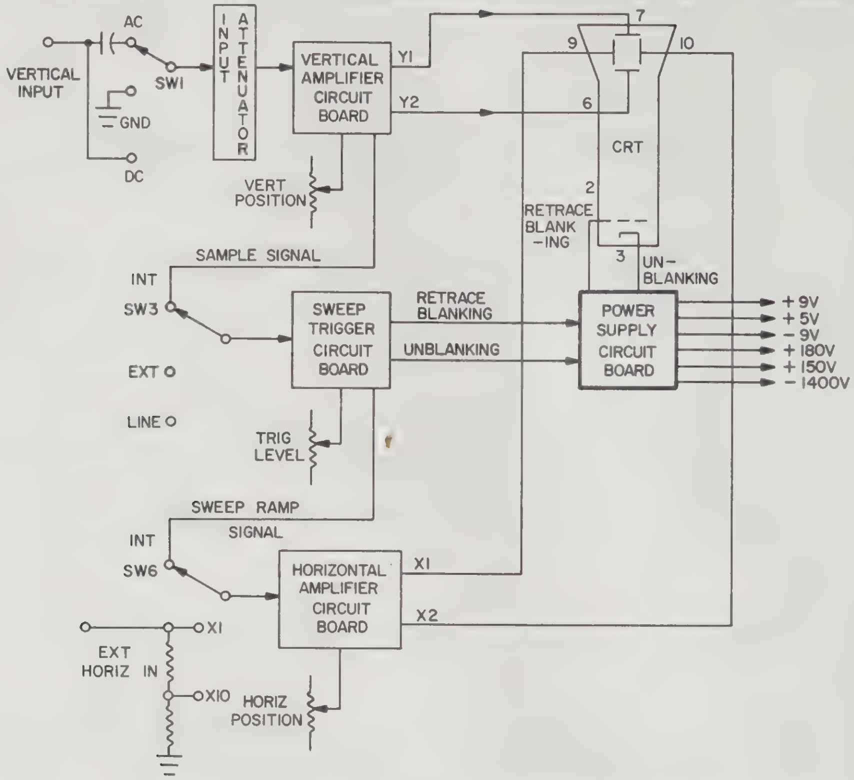


FIGURE 4-1

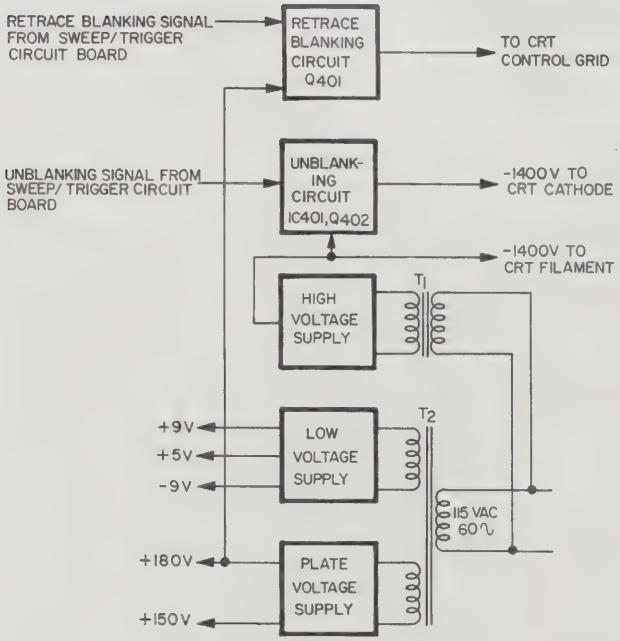

RETRACE BLANKING SIGNAL FROM SWEEP/TRIGGER CIRCUIT BOARD
RETRACE BLANKING CIRCUIT Q401
TO CRT CONTROL GRID
UNBLANKING SIGNAL FROM SWEEP/ TRIGGER CIRCUIT BOARD
UNBLANK- ING CIRCUIT IC401,Q402
-1400V TO CRT CATHODE
-1400V TO CRT FILAMENT
HIGH VOLTAGE SUPPLY
T1
T2
+9V
+5V
-9V
LOW VOLTAGE SUPPLY
115 VAC 60∿
+180V
+150V
PLATE VOLTAGE SUPPLY

FIGURE 4-2

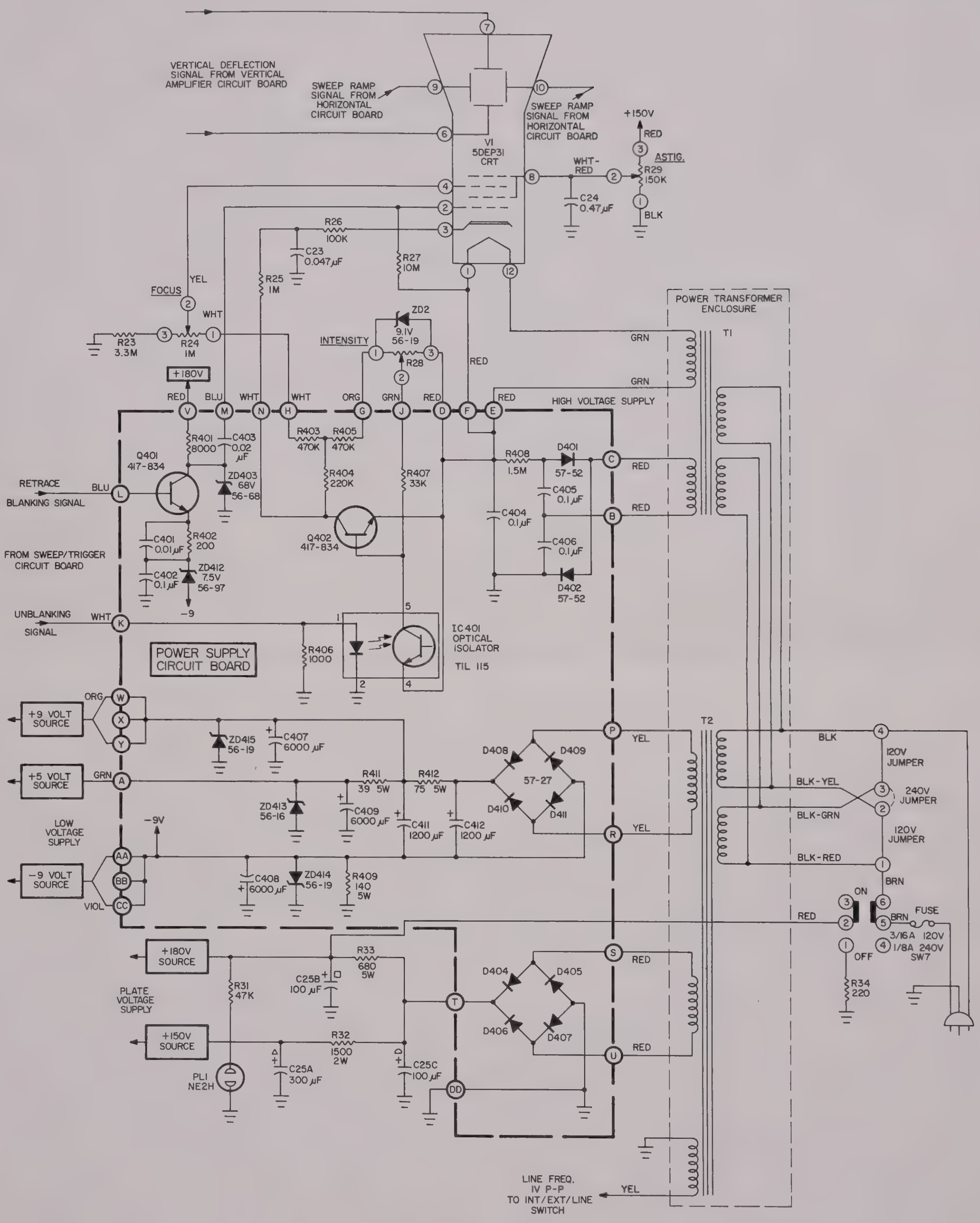
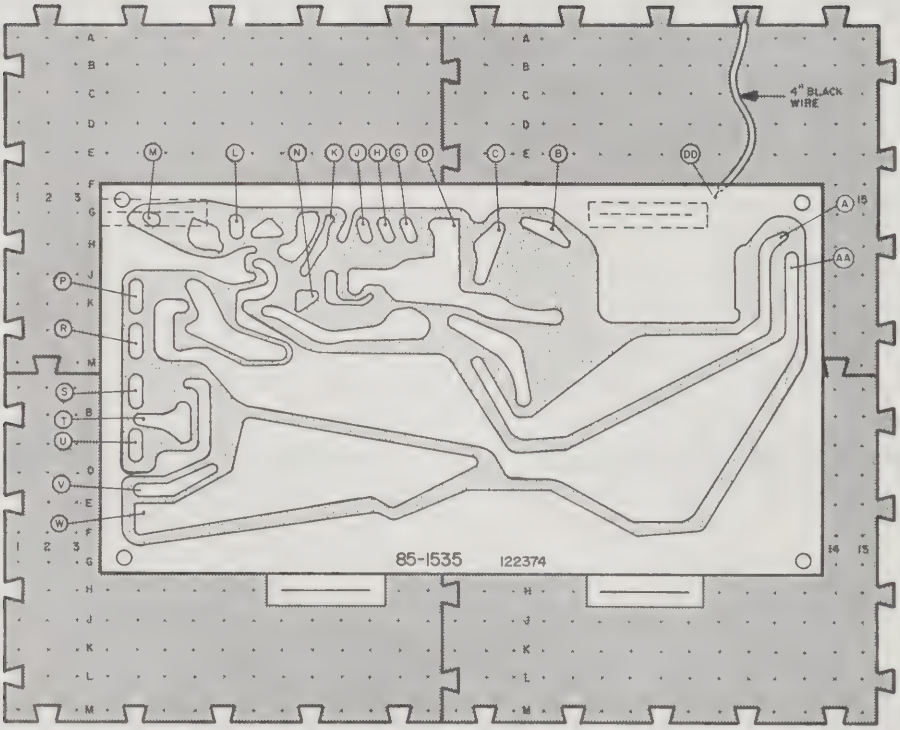

VERTICAL DEFLECTION SIGNAL FROM VERTICAL AMPLIFIER CIRCUIT BOARD
SWEEP RAMP SIGNAL FROM HORIZONTAL CIRCUIT BOARD
SWEEP RAMP SIGNAL FROM HORIZONTAL CIRCUIT BOARD
V1 5DEP31 CRT
+150V
RED
ASTIG.
R29 150K
BLK
WHT-RED
C24 0.47µF
R26 100K
C23 0.047µF
R27 10M
R25 1M
FOCUS
YEL
WHT
R23 3.3M
R24 1M
ZD2 9.1V 56-19
INTENSITY
R28
+180V
RED
BLU
WHT
WHT
ORG
GRN
RED
RED
HIGH VOLTAGE SUPPLY
R401 8000
C403 0.02 µF
R403 470K
R405 470K
Q401 417-834
R404 220K
R407 33K
R408 1.5M
D401 57-52
RED
ZD403 68V 56-68
C405 0.1µF
RETRACE BLANKING SIGNAL
BLU
C404 0.1µF
RED
Q402 417-834
C401 0.01µF
R402 200
C406 0.1µF
FROM SWEEP/TRIGGER CIRCUIT BOARD
C402 0.1µF
ZD412 7.5V 56-97
D402 57-52
-9
UNBLANKING SIGNAL
WHT
IC401 OPTICAL ISOLATOR TIL 115
R406 1000
POWER SUPPLY CIRCUIT BOARD
ORG
+9 VOLT SOURCE
ZD415 56-19
C407 6000µF
YEL
D408
D409
+5 VOLT SOURCE
GRN
R411 39 5W
R412 75 5W
57-27
ZD413 56-16
C409 6000µF
D410
D411
LOW VOLTAGE SUPPLY
-9V
C411 1200µF
C412 1200µF
YEL
-9 VOLT SOURCE
C408 6000µF
ZD414 56-19
R409 140 5W
VIOL
+180V SOURCE
R33 680 5W
C25B 100µF
RED
D404
D405
PLATE VOLTAGE SUPPLY
R31 47K
D406
D407
+150V SOURCE
R32 1500 2W
RED
PL1 NE2H
C25A 300µF
C25C 100µF
LINE FREQ. 1V P-P TO INT/EXT/LINE SWITCH
YEL
POWER TRANSFORMER ENCLOSURE
T1
GRN
GRN
T2
BLK
120V JUMPER
BLK-YEL
240V JUMPER
BLK-GRN
120V JUMPER
BLK-RED
BRN
ON
RED
BRN
FUSE
3/16A 120V
1/8A 240V
SW7
OFF
R34 220

FIGURE 4-3

Figure 4-3 is a foldout and is inserted in the back of this Manual.

FIGURE 4-3


4" BLACK WIRE
M
L
N
K
J
H
G
D
C
B
DD
A
AA
P
R
S
T
U
V
W
85-1535
122374
1
2
3
14
15

LAYOUT 4-1

POINT	RESISTANCE	YOUR READING
AA	71Ω	
A	∞	
B	∞	
C	∞	
D	∞	
G	∞	
H	∞	
J	∞	
K	128Ω	
N	∞	
L	∞	
M	∞	
P	∞	
R	∞	
S	∞	
T	∞	
U	∞	
V	∞	
W	∞	

TABLE 4-1

POINT	RESISTANCE	YOUR READING
AA	140Ω	
A	72Ω	
B	∞	
C	∞	
D	∞	
G	∞	
H	∞	
J	∞	
K	1 kΩ	
N	∞	
L	∞	
M	∞	
P	175Ω	
R	175Ω	
S	65Ω	
T	130Ω	
U	68Ω	
V	13 kΩ	
W	72Ω	

TABLE 4-2

QUESTIONS

IMPORTANT — These instructions **MUST** be accurately followed to avoid loss, or errors in grading.

Indicate your answer on this sheet by filling in the box for the most correct answer to each question.

When all questions have been answered, place the answer card in the proper position to line up the boxes on the card with the boxes on the sheet.

Next, copy the complete lesson code into the space provided on the card, and fill in the answer boxes to correspond with those previously filled in on this sheet.

Before mailing, be certain your correct student number, name and address appear on the card.

LESSON CODE
9575-2A

1. A ☐ B ☐ C ☒ D ☐

Assume SW5 is in the NORM position and no trigger pulses are applied to IC301C, pin 9. Which of the following circuit conditions are present? (Refer to Figure 3-4)
(A) The base of Q310 is high, ramp is being generated. (B) The base of Q310 is low, ramp is being generated. (C) The base of Q310 is high, no ramp is generated. (D) The base of Q310 is low, no ramp is generated.

2. A ☐ B ☐ C ☐ D ☐

Clock pulses at pin 12 of IC303 will cause it to change states when (Refer to Figure 3-4)
(A) pin 13 is high, pin 2 is low. (B) pin 13 is low, pin 2 is high. (C) pin 13 is low, pin 2 is low. (D) pin 13 is high, pin 2 is high.

3. A ☐ B ☒ C ☐ D ☐

When a trigger signal is applied to pin 3 of IC302, the voltage level at pin 6 (Refer to Figure 3-4)
(A) goes high. (B) goes low. (C) goes high then low. (D) remains the same.

4. A ☐ B ☐ C ☐ D ☒

What is the main purpose of the signal at pin 6 of IC303? (Refer to Figure 3-4)
(A) It is used to blank the CRT during sweep time. (B) It is used to unblank the CRT during retrace time. (C) It is used to unblank the CRT during sweep time. (D) It is used to blank the CRT during retrace time.

5. A ☐ B ☒ C ☐ D ☐

When a negative signal is present at point K of the Power Supply Circuit Board (Refer to Figure 4-3)
(A) Q402 blanks the CRT during sweep. (B) Q402 unblanks the CRT during sweep. (C) Q402 unblanks the CRT during retrace. (D) Q402 blanks the CRT during retrace.

6. A ☐ B ☐ C ☐ D ☐

7. A ☐ B ☐ C ☐ D ☐

THIS EXAM CONTAINS ONLY FIVE QUESTIONS

8. A ☐ B ☐ C ☐ D ☐

9. A ☐ B ☐ C ☐ D ☐

10. A ☐ B ☐ C ☐ D ☐

PROJECT 5

CHASSIS ASSEMBLY AND CALIBRATION PROCEDURE

PARTS NEEDED

IOD-4540 Chassis Assembly Parts

1 - Type 7400 Integrated Circuit

1 - IN4004 Silicon Diode

1 - 100Ω, 1/2 W, 20% Resistor

1 - 390Ω, 1/2 W, 10% Resistor

1 - 470Ω, 1/2 W, 20% Resistor

1 - 560Ω, 1/2 W, 10% Resistor

1 - 3900Ω (3.9 kΩ), 1/2 W, 10% Resistor

1 - .01 μF, 100V, Disc Capacitor

1 - 14 pin Integrated Circuit Socket

17 - Modular Connectors

No. 22 Hookup Wire

DISCUSSION

In this project you will assemble the oscilloscope chassis and mount the boards assembled in projects 1 through 4. Also, you will calibrate the scope for proper operation.

PROCEDURE

TEST NO. 1

CHASSIS ASSEMBLY

1. The components for the assembly of the chassis are included in WBS-3. Also included are parts necessary for performing the calibration procedure of test 2 in this project.

2. Refer to the Assembly and Operation Manual which provides step-by-step instructions for assembling the chassis.

3. The list of parts required for the assembly of the chassis is on pages 53 to 61 of the assembly manual. Check the parts you received in shipment WBS-3 against the parts list on pages 53 to 61 to ensure that you received all of the required parts. If any part is missing or defective, follow the instructions in the assembly manual. You should also have a separate bag with experimental parts. There should be two parts in the experimental bag: an IC (type 7400) and a 560Ω, 1/2 W resistor.

4. Follow the assembly procedures given on pages 62 through 109 of the Assembly and Operation Manual. Be sure your soldering iron is clean and properly tinned. Take your time and be sure that all components are properly installed and all solder connections are properly made. There are some connections that are close. So be careful to avoid solder bridges.

5. After you have completed the assembly of the Chassis, visually inspect it to see that all connections have been properly made and soldered. Then perform the Initial Test on page 111 of the Assembly and Operation Manual.

6. After you have completed the assembly and initial test, perform the steps in Test No. 2 of this project.

TEST NO. 2

CALIBRATION PROCEDURE

In this project you will set the circuit board and front panel controls of your Oscilloscope for proper operation. To do this you will need a high input impedance voltmeter. Perform the adjustments exactly as instructed and DO NOT connect the line cord to an AC outlet until you are instructed to do so.

Refer to Figure 1-2 in the Illustration Booklet for the following steps.

Set the front panel controls as follows:

( ) INTENSITY: Fully clockwise.

( ) FOCUS: Center of rotation.

( ) TRIG LEVEL: Center of rotation.

( ) HORIZ POS: Center of rotation.

( ) TIME/CM: ×10.

( ) SWEEP VAR/HORIZ GAIN: Fully clockwise.

( ) VOLTS/CM: .02.

( ) VARIABLE: Fully clockwise.

( ) VERT POS: Center of rotation.

( ) AC-GND-DC: GND

( ) OFF-ON switch: OFF.

( ) INT-EXT-LINE switch: INT.

( ) AC-DC-TV switch: AC.

( ) POSITIVE (+) NEGATIVE (-) switch: +.

( ) AUTO-NORMAL switch: AUTO.

( ) Set the ASTIGMATISM control on the chassis (see Figure 1-3 in the Illustration Booklet) to the center of its rotation.

Set the following controls on the Vertical Amplifier Circuit Board as follows.

( ) DC LEVEL: Center of rotation.

( ) POS ADJ: Center of rotation.

( ) PLATE VOLTS ADJ: Center of rotation.

( ) VERTICAL CAL: Center of rotation.

( ) DC BAL: Center of rotation.

( ) TRIMMER C107: Turn the screw down until it is snug. Then turn the screw counterclockwise 3/4 of a turn.

Set the following controls on the horizontal amplifier circuit board as follows:

( ) SWEEP LENGTH: Center of rotation.

( ) PLATES VOLTS ADJ: Center of rotation.

( ) DC BAL: Center of rotation.

Set the following controls on the sweep-trigger circuit board as follows:

( ) SWEEP CAL: Center of rotation.

( ) LEVEL SET: Center of rotation.

CAUTION: Voltages in some areas of the oscilloscope may exceed 1300 volts. Be very careful when you make the following adjustments. Make sure the oscilloscope is set on a nonmetallic surface and is not within reach of a water pipe or other ground conductor. The dangerous voltage areas are shown on pages 150 and 151 of the Assembly Manual.

( ) Connect the oscilloscope line cord to an AC outlet.

( ) Connect the negative voltmeter lead to the chassis of the oscilloscope.

( ) Set the voltmeter to measure 1.5 volts DC.

NOTE: If you do not get the proper results in the following steps, recheck the steps to make sure you have adjusted the correct controls.

( ) Set the ON-OFF switch on the oscilloscope to the ON position. The red POWER lamp should light. Allow the oscilloscope at least one minute to warm up.

VERTICAL AMPLIFIER ADJUSTMENTS

Perform the following adjustments on the Vertical Amplifier Circuit Board.

Refer to Figure 1-3 in the Illustration Booklet for the following steps.

( ) Touch the meter probe to the front lug of the VERT CAL control and adjust the DC BAL (DC Balance) control to obtain a zero volt reading. Check for both a positive and negative voltage.

( ) Set the voltmeter to measure 150 volts DC.

( ) Alternately measure the Q109 and Q110 collector voltages at the metal tabs on top of the transistors. Adjust the POS ADJ (Position Adjust) control until both collector voltages are the same. NOTE: As the voltage at one collector decreases, the voltage at the other collector will increase. If this does not occur, recheck the VERT POS control on the front panel to ensure it is in the center of the rotation.

( ) Again measure the voltage at the Q109 and Q110 collectors. Turn the PLATE VOLTS ADJ control to obtain 80 volts at each collector. NOTE: If the voltage at both collectors is not the same, repeat the previous step and then return to this step.

Vertical Balance Adjustment

( ) Turn the VARIABLE control on the front panel full counterclockwise.

( ) Using the VERT POS (Vertical Position) control on the front panel, position the dot on the CRT so it is on one of the horizontal graticule lines.

( ) Now turn the VARIABLE control fully clockwise. If the dot moves up or down, adjust the DC BAL control on the Vertical Amplifier Circuit Board to reposition the dot back on the line.

( ) Repeat the previous three steps until there is no movement.

NOTE: Because of the normal aging of your oscilloscope, you may have to repeat this adjustment periodically. To determine if the adjustment is necessary, turn the VARIABLE control from one end to the other and see if the dot (or trace) moves up or down. It should remain in the same place.

HORIZONTAL AMPLIFIER ADJUSTMENTS

Perform the following adjustments on the Horizontal Amplifier Circuit Board.

( ) Set the voltmeter to measure 1.5 volts DC.

Refer to Figure 1-3 of the Illustration Booklet for the following steps.

( ) Touch the meter probe to the collector (C) lead of transistor Q202 and adjust the DC BAL (DC Balance) control to obtain a zero volt reading. Check for both a positive and negative voltage.

( ) Set the voltmeter to measure 150 volts.

( ) Alternately measure the Q207 and Q208 collector voltages at the metal tabs on top of the transistors. Adjust the HORIZ POS (Horizontal Position) control on the front panel until they are equal. NOTE: As the collector voltage on one transistor decreases, the collector voltage on the other transistor will increase.

( ) Again measure the Q207 and Q208 collector voltages at the metal tabs on top of the transistors. Turn the PLATE VOLTS ADJ control to obtain 90 volts on the metal tabs. NOTE: If the voltage on both transistor tabs is not the same, repeat the previous step and then return to this step.

Horizontal Balance Adjustment

( ) Turn the SWEEP VAR/HORIZ GAIN control fully counterclockwise.

( ) Using the HORIZ POS (Horizontal Position) control on the front panel, position the dot on the CRT so it is on one of the vertical graticule lines.

( ) Now turn the SWEEP VAR/HORIZ GAIN control fully clockwise. If the dot moved left or right, adjust the DC BAL control on the Horizontal Amplifier Circuit Board to reposition the dot back on the line.

( ) Repeat the previous three steps until there is no movement.

NOTE: Because of the normal aging of your oscilloscope, you may have to repeat this adjustment periodically. To determine if the adjustment is necessary, turn the SWEEP VAR/HORIZ GAIN control from one end to the other and see if the dot (or trace) moves left or right. It should remain in the same place.

TRIGGER CIRCUITS

Make the following adjustments on the front panel.

Refer to Figure 1-2 of the Illustration Booklet for the following steps.

( ) Adjust the FOCUS control to obtain the smallest, sharpest spot of light on the CRT.

( ) Adjust the ASTIGMATISM control on the chassis (refer to the Illustration Manual Figure 1-3) to obtain the smallest, sharpest spot of light on the CRT.

( ) Set the TIME/CM selector to the 2 mS position.

( ) Make sure that the VARIABLE control on the TIME/CM selector is turned fully clockwise.

Refer to Figure 1-3 of the Illustration Booklet for the following steps.

( ) Set the voltmeter to measure 1.5 volts DC.

( ) Touch the meter probe to the S (source) lead of transistor Q301 on the Sweep/Trigger Circuit Board and turn the LEVEL SET control to obtain a zero volt reading. Check for both a positive and negative voltage.

( ) Disconnect the voltmeter and set it aside.

( ) Inspect the trace on the CRT to see if it is parallel with the horizontal lines on the graticule.

1. ( ) Grasp the CRT just back from the front panel and turn the tube while noticing the relationship of the trace to the graticule lines. Turn the tube to make the trace parallel with the graticule lines.

2. ( ) Make sure the CRT is positioned fully forward. Then tighten the CRT clamp screws. Tighten these screws only enough to keep the CRT from moving.

Trimmer Preset

Refer to Figure 1-5 in the Illustration Booklet for the location of the trimmer screws.

( ) Disconnect the line cord from the AC outlet.

( ) Position the oscilloscope on its right side (transformer cage side).

NOTE: To adjust the trimmer screws, you must insert the screwdriver through the holes in the shield.

( ) Adjust the trimmer screws (C2-A, C2-B, C2-C) down until they are snug but not tight.

( ) Turn out the screw in trimmer C2-A exactly 3/4 turn.

( ) Turn out the screw in trimmer C2-B exactly 3/4 turn.

( ) Turn out the screw in trimmer C2-C exactly 3/4 turn.

( ) Position the oscilloscope back in its normal operating position.

SWEEP CALIBRATION

( ) Reconnect the line cord to the AC outlet.

( ) Adjust the HORIZ POS control on the front panel so that the trace starts at the left vertical line on the graticule.

( ) Adjust the SWEEP LENGTH control on the Horizontal Amplifier Circuit Board (refer to Figure 1-3) so that the trace ends at the right vertical line of the graticule.

( ) Now turn the HORIZ POS control on the front panel so that the trace moves left exactly two centimeters. (Each square is a centimeter.) At this time the trace should end on a vertical line two centimeters from the right side of the graticule.

( ) Again, adjust the SWEEP LENGTH control on the horizontal amplifier circuit board so that the trace ends at the right vertical line of the graticule.

( ) Adjust the HORIZ POS control on the front panel so the trace starts at the left vertical line on the graticule. The trace is now adjusted to exactly 12 centimeters in length. However, since there is only room to display 10 centimeters of trace on the face of the CRT, the other two centimeters of trace are off the CRT screen to the right.

( ) Apply the 1V (P-P), 60 Hz signal to the vertical INPUT of the oscilloscope. (Use a meter lead.)

( ) Set the TIME/CM selector to the 2 mS position.

( ) Set the VOLTS/CM (volts per centimeter) control on the front panel to the 1 position. Make sure that the VARIABLE control remains fully clockwise.

( ) Set the AC-GND-DC switch to AC.

NOTE: In the next step it is not necessary to have the full sinewave displayed on the CRT. Only the leading part of the trace (on the left side of the CRT) will be used in this adjustment.

( ) Adjust the TRIG LEVEL (trigger level) control on the front panel to obtain a stable display.

( ) Center the display on the CRT by adjusting the VERT POS control.

( ) Now adjust the TRIG LEVEL control to obtain a trace that starts on the center horizontal line. (Make sure the display is centered on the CRT.)

( ) Set the AC-DC-TV switch to DC.

( ) Adjust the DC LEVEL control on the vertical amplifier circuit board to obtain a stable display with a trace that begins on the center horizontal line on the CRT.

( ) Now switch the AC-DC-TV switch back and forth between the AC and DC positions. The display should remain stable and the trace should begin at the same place in both positions. Repeat the DC LEVEL adjustment if necessary.

( ) Disconnect the 1V P-P, 60 Hz signal from the vertical INPUT.

( ) Set the TRIGGERING switches to: INT, AC, +, AUTO.

( ) Adjust the SWEEP VAR/HORIZ GAIN control fully clockwise.

( ) Apply the 1V (P-P), 60 Hz signal to the vertical INPUT of the scope.

( ) Set the VOLTS/CM switch to the 0.2 position.

( ) Adjust the SWEEP CAL on the Sweep/Trigger Circuit Board (refer to Figure 1-3 in the Illustration Booklet) so that 1 cycle covers 8 cm.

( ) Disconnect the 1V P-P, 60 Hz signal from the vertical INPUT.

( ) Connect the scope cable to the vertical INPUT jack.

( ) Connect the shield of the scope cable to the design console REG DC (-) terminal and the center conductor of the scope cable to the design console sinewave (∿) output terminal.

( ) Set the VOLTS/CM switch to the 2 position.

( ) Set the design console OFF-6V-30V switch to the 6V position. NOTE: Be sure the ADJUST VOLTAGE control is in the fully counterclockwise (minimum) position.

( ) Turn the design console ADJUST FREQ control fully counterclockwise, then fully clockwise. NOTE: Observe that the trace remains stable as frequency changes when the ADJUST FREQ control is rotated.

( ) Apply the 1V P-P signal of the scope to the EXT INPUT (horizontal input) jack.

( ) Set the TIME CM switch to the EXT ×1.

( ) Adjust the HORIZ POS control to center the trace. NOTE: The reason for this shift in trace to the left, after you had already centered the trace in STEP NO. 1, is that this oscilloscope uses a DC horizontal amplifier. The external signal being applied to the horizontal amplifier at this time is an AC signal. The resulting sweep will be to the left as well as the right from the normal static position of the beam. When the TIME/CM switch is in any of the internal sweep positions, a DC sweep voltage is used. The result is that the trace will then sweep from a static zero voltage position (on the left) to a DC voltage level (on the right) as the internal sweep capacitor charges. Going from internal DC to external AC or reverse requires repositioning of the HORIZ POS control.

( ) Slowly adjust the design-console ADJUST FREQ control for a Lissajous pattern like Figure 5-1. Adjust the ADJUST FREQ control for a stable 6 cycle pattern and do not disturb its setting. This calibrates the design-console output frequency to approximately 360 Hz.

( ) Disconnect the 1V P-P signal from the EXT INPUT jack.

( ) Set the TIME/CM switch to the 2 ms position.

( ) Adjust the HORIZ POS control to center the trace. Note that the shift in the position of the trace is caused by the reasons previously discussed.

( ) Connect the center conductor of test lead to the design console square-wave terminal (⎍). Readjust vertical VARIABLE for a 6 cm deflection.

( ) Adjust the oscilloscope HORIZ POS control until the first negative-going edge of the square wave is aligned with the first line on the left edge of the graticule, and top and bottom edges are equal distance above and below the horizontal center line. NOTE: Disregard any distortion in the peaks of the waveform and concentrate on the vertical lines of the waveform.

( ) Adjust the SWEEP CAL control (refer to Figure 1-3 of the Illustration Booklet) so that the fourth negative-going edge of the square wave crosses the horizontal center line at 4.15 CM. (Refer to Figure 5-2). NOTE: You should have three complete square waves starting at the first line on the left edge of the graticule and ending at 4.15 CM to the right.

( ) Adjust the transformer cage (by turning it) for the sharpest, clearest trace on the CRT. NOTE: In some cases no change in the trace will be observed. If this occurs, position the transformer as shown in Figure 1-4 of the Illustration Booklet. The transformer assembly is rotated to the position at which the transformer's magnetic field will have the least effect on the electron beam of the CRT.

( ) Place the AC-GND-DC switch in the AC position.

( ) Turn off the oscilloscope, disconnect the generator, and disconnect the line cord from the AC outlet.

( ) Turn the oscilloscope over, making sure that the transformer assembly does not change position.

( ) Refer to Figure 1-4 of the Illustration Booklet and move the transformer cage so that a screw hole in the cage lines up with the nearest hole in the chassis. Then install a 6-32 × 1/4" sheet metal screw in the hole to keep the transformer case from moving. Also, tighten the four screws in the grommet plate.

( ) Turn the oscilloscope over and connect the line cord to an AC outlet.

VERTICAL COMPENSATION

( ) Construct the signal generator circuit shown in Figure 5-3 and Layout 5-1 of this manual. (The wiring of the IC socket is shown in Figure 5-4.) Be sure that the IC is properly inserted into its socket. However, do not connect the red and black wires to the - and + terminals of the regulated power supply. Instead, turn on the design console. Measure the regulated dc output voltage and adjust it to 5 volts. Then connect the red and black wires to the power supply terminals. Remeasure the regulated dc output voltage and, if necessary, readjust it to 5 volts.

( ) Connect the Low Output of the signal generator (see Layout 5-1) to the vertical INPUT of the scope. (Connect the center conductor of the test lead to the Low Output connector and the shield to the other terminal at R5.)

( ) Set the VOLTS/CM switch to the .02 position and the vertical VARIABLE control fully clockwise.

( ) Turn on the oscilloscope.

( ) Set the TIME/CM switch to 2 µS.

( ) Adjust the Trigger Level control as necessary to obtain a stable pattern.

( ) Adjust the screw in the VERTICAL COMPENSATION trimmer, C107, (see Figure 1-3 in the Illustration Booklet) on the vertical amplifier circuit board until the square wave appears as close as possible to that shown in Figure 1-6 of the Illustration Booklet.

( ) Turn off the scope, turn off the Design Console, disconnect the red and black wires from the regulated dc output terminals and disconnect the scope leads from the signal generator circuitry.

VERTICAL ATTENUATOR ADJUST

( ) Connect the shield of the oscilloscope test lead to the design console - REG DC terminal.

( ) Connect the inner conductor of the scope test lead to the design console square-wave terminal.

( ) Turn on the design console and set the ADJUST FREQ. control fully clockwise.

( ) Disconnect the scope line cord from the ac outlet; position the scope on its left side; reconnect the scope line cord to the ac outlet.

( ) Set the VOLTS/CM switch to the 5 position.

( ) Set the TIME/CM switch to 200 µS; adjust the horizontal VARIABLE control to display several cycles on the CRT. If necessary, adjust the Trigger Level control for a stable pattern.

( ) Using an insulated screwdriver or alignment tool, adjust the screw in trimmer C2-B (see Figure 1-7 in the Illustration Manual) to obtain a waveform that appears like the one shown in Figure 1-6 in the Illustration Manual.

( ) Turn the VOLTS/CM switch to the 2 position.

( ) Turn the VARIABLE control to produce approximately a 6 centimeter display (vertically) on the CRT.

( ) Turn the screw in trimmer C2-C to obtain a waveform that appears like the one shown in Figure 1-6 in the Illustration Manual.

( ) Repeat the last six "Vertical Attenuator" adjustments until there is no further improvement.

NOTE: If you have a low capacity probe, perform the steps under "With Low Capacity Probe" in the Assembly and Operation Manual, page 118. If you do not have a low capacity probe, proceed to "Without Low Capacity Probe" on page 118 of the Assembly Manual.

( ) Disconnect the line cord from the AC outlet and position the oscilloscope in its normal operating position. Then reconnect the line cord to the AC outlet.

VERTICAL CALIBRATION

( ) Set the TIME/CM selector to the 2 mS position.

( ) Set the VOLTS/CM selector to the 0.2 position. Make sure the VARIABLE is fully clockwise.

( ) Apply the 1V (P-P), 60 Hz signal on the oscilloscope front panel to the vertical INPUT connector.

( ) Set the AC-GND-DC switch to AC.

( ) Adjust the SWEEP VAR/HORIZ GAIN (Sweep Variable/Horizontal Gain) control to produce several cycles on the CRT.

( ) Refer to Figure 1-3 in the Illustration Booklet and turn the VERT CAL (Vertical Calibration) control on the Vertical Amplifier Circuit Board to obtain 5 centimeters of vertical deflection.

( ) Turn off the oscilloscope and disconnect the line cord from the AC outlet.

NOTE: It is suggested that you repeat the "Calibration" after your oscilloscope has operated several hours, and periodically thereafter. Each time, allow sufficient warm-up time (at least 30 minutes) before you start calibration.

This completes the calibration. Proceed to "Final Assembly" in the Assembly and Operation Manual.

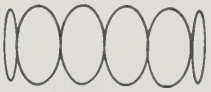


FIGURE 5-1

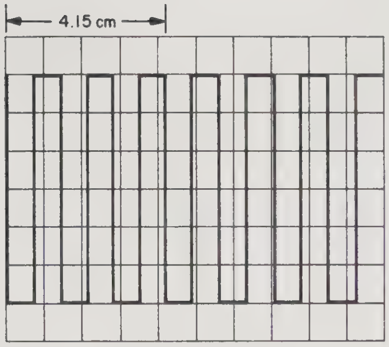


FIGURE 5-2

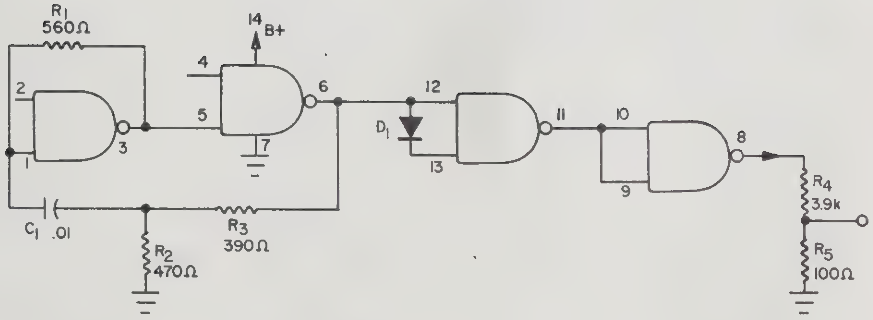


FIGURE 5-3

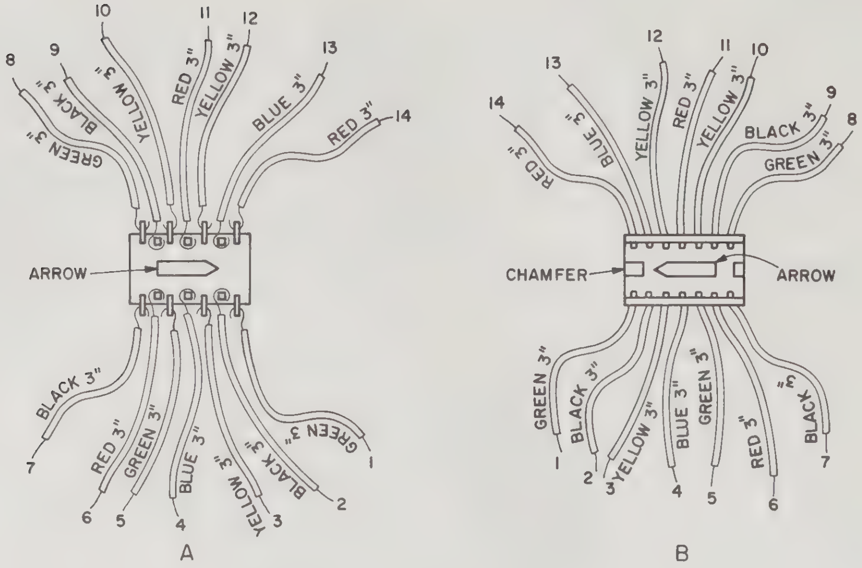
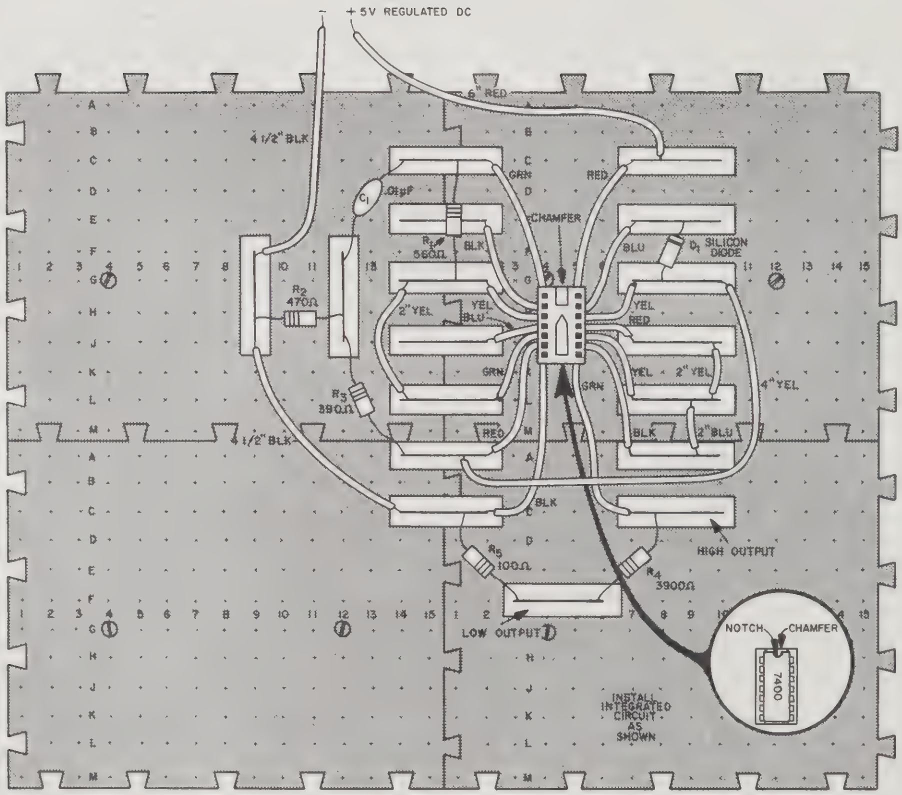


FIGURE 5-4



LAYOUT 5-1

PROJECT 6

OSCILLOSCOPE OPERATION

PARTS NEEDED

1 - Completed Oscilloscope with Test Leads

1 - Design Console

1 - Silicon Diode

1 - 100Ω, 1/2W, 20% Resistor

1 - 390Ω, 1/2W, 10% Resistor

1 - 470Ω, 1/2W, 20% Resistor

1 - 1 kΩ, 1/2W, 20% Resistor

2 - 10 kΩ, 1/2W, 10% Resistors

1 - 1 MΩ Potentiometer with Leads and Bracket

1 - .1 μF, 100V dc Disc Capacitor

1 - 10 μF, 50V dc Electrolytic Capacitor

15 - Modular Connectors

- No. 22 Solid Hookup Wire

2 - Tri-Mounts

1 - Pair Test Leads with Spring Adapters

This project contains several experiments designed to help you become proficient in the use of your scope.

EXPERIMENT 1

TRIGGERING THE OSCILLOSCOPE

PARTS NEEDED

1 - Design Console

1 - .1 μF, 100V Disc Capacitor

1 - Oscilloscope with Test Leads

1 - 1 MΩ Potentiometer with Leads and Brackets

4 - Modular Connectors

2 - Tri-Mounts

DISCUSSION

The triggered sweep oscilloscope displays a stable pattern on the face of its CRT by synchronizing its horizontal sweep generator with wavefronts of the repeating input signal. A sample of the input signal is taken from the vertical amplifier of the scope and applied to the triggering circuits of the horizontal sweep generator for synchronization.

The TRIGGERING INT/EXT/LINE switch on the front panel selects either an internal trigger (a sample signal from the vertical amplifiers) or an external trigger (a signal from an external circuit connected to the EXT TRIG jack). In the LINE position, 1 V p-p 60 Hz signal is applied to the triggering circuitry.

The Horizontal TIME/CM switch determines the horizontal sweep time by selecting one of the five timing capacitors (C8 to C13) and one of the three timing resistors (R15, R16, R17). A positive-going ramp waveform is generated by the charge and discharge action of the timing capacitor. The larger the value of the timing capacitor and the timing resistor, the lower the frequency of the ramp waveform.

When observing waveforms other than sinewaves, you will find that one polarity of triggering voltage may cause a more stable display than the other polarity. Therefore, a TRIGGERING + switch appears on the front panel of the oscilloscope that enables you to select the proper polarity trigger signal. The TRIG/LEVEL control is then adjusted for a stationary pattern on the face of the CRT. The TRIG/LEVEL control should not be rotated too far clockwise, however, or the waveform on the CRT screen will not lock in.

PROCEDURE

1. Set up the circuit in Figure 6-1 on the design console.
2. Plug in and turn on the design console.
3. Turn on your oscilloscope and allow a one minute warm-up period.

TEST NO. 1

EXTERNAL TRIGGERING

1. Make the preliminary oscilloscope adjustments as follows:
    - A. Set the VOLTS/CM switch to the 5 position, adjust the VARIABLE control to the CAL position (fully clockwise), set the AC/GND/DC switch to the AC position.
    - B. Set the horizontal TIME/CM switch to 2 mS, and the SWEEP VAR/HORIZ GAIN control to the CAL position (fully clockwise).
    - C. Set the TRIGGERING switches to AUTO, +, AC, and INT positions.
    - D. Adjust the INTENSITY control fully clockwise.
    - E. Adjust the TRIG LEVEL control to obtain a trace.
    - F. Readjust the INTENSITY control for a trace of normal brightness.
    - G. Adjust the HORIZ and VERT position controls to center the trace.
    - H. Adjust the FOCUS control so that the trace is as sharp as possible.
2. Use the red test lead from your DMM to connect from the EXT TRIG INPUT jack to point C.
3. Connect the shield of your scope lead to the ground point in the circuit.
4. Connect the center conductor of your scope lead to point A.
5. Place INT/EXT/LINE switch to the EXT position.

6. Adjust the TRIG LEVEL control for a stable pattern display.

7. Adjust the Horizontal VARIABLE control for two cycles. The scope's pattern should have the appearance of Figure 6-2.

8. Being careful not to disturb the setting of any of the scope controls, observe the voltage at point B. Move the center conductor test lead to point B to do this.

9. Adjust potentiometer R_1 from one extreme to the other and notice that the phase of the observed sinewave shifts.

10. In the EXT sweep trigger position, the oscilloscope is being triggered by the external signal. Therefore, any change in phase at the vertical input is displayed.

TEST NO. 2

INTERNAL TRIGGERING

1. Disconnect the test lead between point C and the EXT TRIG INPUT jack.

2. Place the TRIGGERING INT/EXT/LINE switch to the INT position. Do not change any of the other control settings.

3. Connect the center conductor of the scope lead to point C.

4. If necessary, adjust the TRIG LEVEL control for a stable trace. The pattern should be similar to Figure 6-3.

5. Connect the center conductor of your scope lead to point B.

6. Vary R_1 from one extreme to the other and notice that the waveshape remains as shown in Figure 6-3. This is because the oscilloscope is being triggered by the same signal that is being displayed.

7. Place the TRIGGERING +/- switch to the - position. Your pattern should have the appearance of that shown in Figure 6-2. The oscilloscope is now being triggered by the first negative-going alternation.

8. Turn off the design console.

TEST NO. 3

TRIGGERING THE OSCILLOSCOPE IN THE NORMAL MODE

1. Set the VOLTS/CM switch to the 5.0 position, adjust the VARIABLE control to the CAL position, and set the AC/GND/DC switch to the AC position.

2. Set the TIME/CM switch to 200 µS, and the SWEEP VAR/HORIZ GAIN control to the CAL position.

3. Set the TRIGGERING switches to NORMAL, +, AC and INT positions.

4. Turn the TRIG LEVEL control fully counterclockwise.

5. Connect the shield (ground) of your scope lead to the -DC REG binding post of the design console's power supply.

6. Connect the center conductor of your scope lead to the squarewave output of the design console.

7. Set the design console frequency adjustment control to the maximum clockwise position.

8. Turn on the design console.

9. Slowly adjust the TRIG LEVEL control. The pattern will first appear, and then it will lock into place. Further adjustment will cause the pattern to become unstable.

10. Readjust the TRIG LEVEL control for a stable pattern.

11. Turn off the design console.

EXPERIMENT 2

VOLTAGE AMPLITUDE MEASUREMENT

PARTS NEEDED

1 - Oscilloscope with Test Leads

1 - Design Console

3 - Modular Connectors

No. 22 Solid Hookup Wire

1 - 100Ω, 1/2W, 20% Resistor

1 - 1 kΩ, 1/2W, 5% Resistor

2 - 10 kΩ, 1/2W, 20% Resistors

DISCUSSION

The oscilloscope is one of the most useful test instruments available to the technician. One important feature of the oscilloscope is that it can be used to measure peak-to-peak voltage by observing the waveform of the signal.

The vertical amplifier in your Triggered Sweep oscilloscope is calibrated to measure the peak-to-peak amplitudes of ac voltages in nine ranges extending from .02 to 10 p-p volts per centimeter. The nine voltage ranges of the VOLTS/CM selector switch are: 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10. These values designate the peak-to-peak signal voltages required to deflect the CRT trace 1 cm in the vertical direction when the VARIABLE control is in the CAL (calibrated) position. To find the p-p voltage amplitude of any waveform being observed, you simply multiply the waveform's vertical deflection in centimeters by the value indicated by the position of the VOLTS/CM switch. This gives the peak-to-peak amplitude of the voltage waveform.

For example, assume that a signal applied to the INPUT causes a vertical deflection of 5 centimeters with the VOLTS/CM switch set to the 0.02 position, and the VARIABLE control in the CAL position. The position of the VOLTS/CM switch indicates that each centimeter of deflection equals .02 volt p-p; so you multiply the 5 centimeters of deflection by .02. This gives a value of .10 volt p-p for the waveform being observed. If the VOLTS/CM switch were in the 10 position and there were 3 cm of deflection, you would multiply the 3 centimeters by 10 for a reading of 30 volts p-p.

The oscilloscope may be calibrated to an external ac voltage source, provided that the peak-to-peak value of the reference voltage is known. For this calibration, adjust the Vertical VARIABLE control so that the external voltage source causes a vertical deflection of any number of centimeters that you choose.

For example, assume that you want to calibrate the scope to a 1 volt p-p voltage source. Set the VOLTS/CM switch to the 1 position, and apply the 1 volt p-p signal to the vertical input terminals of the scope. Next, set the VARIABLE control for a deflection of 1 cm. Each vertical cm on the graticule now has a value of 1 volt p-p.

WHEN THE VARIABLE CONTROL IS RESET FROM THE CAL POSITION, THE CALIBRATION OF THE VOLTS/CM IS NO LONGER VALID. However, changing the position of the VOLTS/CM switch still changes the sensitivity factor of the vertical amplifier. Depending upon the position of the VOLTS/CM switch when the scope was calibrated, you multiply or divide the amount of deflection in cm. The VARIABLE control MUST NOT BE RESET if that calibration is to be retained.

To illustrate this, suppose that you have calibrated the scope for 1 volt p-p/cm on the 1 setting of the VOLTS/CM switch. If you set the switch to the 10 position, the sensitivity of the vertical amplifier DECREASES by a factor of 10, and each cm of deflection now has a value of 10 volts p-p. Similarly, if you set the VOLTS/CM switch from the 1 to the .1 position, the sensitivity INCREASES by a factor of 10 and each cm of deflection has a value of only .1 volt p-p.

Like any other sensitive instrument, the oscilloscope can be overloaded, causing the displayed waveform to be distorted. To avoid overloading, set the VOLTS/CM switch to the least sensitive position (10); if the pattern is not large enough, set the VOLTS/CM switch to a more sensitive position.

TEST NO. 1

AC VOLTAGE MEASUREMENT

1. Turn on the design console.

2. Turn on your oscilloscope and allow it to warm up.

3. Make the preliminary oscilloscope adjustments as follows:

   A. Set the TIME/CM switch to 2 ms.

   B. Set the SWEEP VAR/HORIZ GAIN control to the maximum clockwise (CAL) position.

   C. Set the VOLTS/CM switch to the 5.0 position.

   D. Set the VARIABLE control to the maximum clockwise (CAL) position.

   E. Set the TRIGGERING switches to: AUTO, +, INT.

   F. Adjust the INTENSITY control so that the trace brightness is at a comfortable viewing level.

   G. Adjust the VERT POS and HORIZ POS controls so that the trace is centered.

   H. Adjust the FOCUS control so that the trace is as sharp as possible.

   I. Set the AC/GND/DC switch to the AC position.

4. Use the scope to measure the 6.3 volts ac available from the design console. To do this, connect the shield of the scope lead to the OV binding post on the design console and the center conductor to the 6.3 V binding post.

5. Adjust the TRIG LEVEL control and the SWEEP VAR/HORIZ GAIN control to obtain a two-cycle pattern that is stationary and similar to Figure 6-3. The pattern should be approximately 3.6 centimeters high. Multiplying the deflection in centimeters (3.6) by 5 indicates that the peak-to-peak amplitude is approximately 18 volts. The unloaded output voltage is affected by the line voltage, which may vary.

Notice that the "6.3 volts" applied to the input of the oscilloscope results in an indication of approximately 18 volts peak-to-peak on the screen of the scope. This is because the 6.3 volts applied to the input is the rms value, and the value displayed by the oscilloscope is a peak-to-peak value.

Mathematically, the peak value of a voltage is 1.414 times the rms value and the peak-to-peak value is twice the peak value, or 2.828 times the rms value. Expressed as equations:

$$\text{peak value} = 1.414 \times 4 \text{ rms value}$$

$$\text{peak-to-peak value} = 2.828 \times \text{rms value}.$$

Thus, the peak-to-peak value of 6.3 volts rms is 6.3 × 2.828 = 17.8164, or approximately 18 volts. This is close to the value indicated on the oscilloscope.

TEST NO. 2

AC VOLTAGE MEASUREMENT

1. Set up the circuit of Figure 6-4 on your design console.

2. With the DMM, measure the voltage across R_2. (Black test lead to ground; red test lead to the junction of R_1 and R_2.)

3. R_1 and R_2 form a voltage divider and, depending on component tolerances, the 12.6 volts ac divides between them at a ratio of approximately 10 to 1.

4. Connect the scope probe to the scope and again measure the R_2 voltage. With the VOLTS/CM switch in the 1.0 position and the VARIABLE control maximum clockwise, deflection should be about 4 cm. Since each centimeter (cm) corresponds to 1 volt, this represents approximately 4 volts peak-to-peak.

To compare the voltage values obtained in Steps 2 and 3, convert the rms voltage obtained in Step 2 to a peak-to-peak value or the voltage obtained in Step 3 to an rms value. These values should be close to each other.

5. Change R_2 from a 1 kΩ resistor to a 10 kΩ resistor.

6. Measure the voltage across R_2 with your oscilloscope. Set the VOLTS/CM switch to the 5.0 position (the VARIABLE control is still maximum clockwise). You should get about 4 cm of deflection. Since each cm represents 5 volts, the measured value is about 20 volts peak-to-peak.

7. Change R_2 to a 100Ω resistor. This forms about a 100 to 1 voltage divider with R_1, and with the VOLTS/CM switch in the 0.1 position, you should again get about 4 cm of deflection. But since each cm of deflection now represents only .1 volt, the measured value is about .4 volts peak-to-peak.

TEST NO. 3

DC VOLTAGE MEASUREMENT

1. Turn the design console OFF-6V-30V switch to the 6V position.

2. Measure the output of the REG DC supply with the DMM.

3. Adjust the output voltage for a reading of 4.5 volts on the DMM.

4. Disconnect the DMM.

5. Turn the oscilloscope on and allow it to warm up.

6. Set the VOLTS/CM switch to the 2.0 position.

7. Set the VARIABLE control to the CAL position.

8. Place the AC/GND/DC switch in the DC position.

9. Center the trace.

10. Connect the shield of the scope lead to the (-) REG DC terminal.

11. Connect the center conductor of the scope lead to the (+) REG DC terminals.

12. Notice that the trace moves up approximately 2.25 cm. To calculate a DC voltage, we multiply the number of cm the trace moves by the setting of the VOLTS/CM switch when the VARIABLE control is in the CAL position.

13. Calculate the voltage in Step 12. ____________V dc. The voltage should be approximately 4.5V dc.

14. Place the AC/GND/DC switch in the GND position. Notice that the trace returns to the center of the CRT screen.

15. Turn the design console off.

16. Position the scope's trace 2 cm below the center of the screen.

17. Turn the design console OFF-6V-30V switch to the 30V position.

18. Set the scope's VOLTS/CM switch to the 5.0 position.

19. Place AC/GND/DC switch in the DC position.

20. Indicate the number of cm that the trace moves. __________ cm.

21. Calculate the DC voltage __________ vdc.

22. Measure the DC voltage at the REG DC terminals with the DMM.

The value calculated in Step 21 should be close to the voltage measured with the DMM in Step 22.

EXPERIMENT 3

PHASE MEASUREMENT

PARTS NEEDED

1 - Design Console

1 - Oscilloscope with Test Leads

1 - .1 μF, 100V Disc Capacitor

1 - 1 MΩ Potentiometer with Leads and Bracket

2 - Tri-Mounts

4 - Modular Connectors

DISCUSSION

In simple terms, phase can be defined as the distance between the positive peaks of two sinewaves of the same frequency. This distance is called the "phase angle" and is usually measured in degrees.

Figure 6-5A shows two sinewaves, A and B, of the same frequency. Notice that the positive peak of each sinewave occurs at 90°. The negative peak of each sinewave occurs at 270°, and each sinewave crosses the zero axis at 0°, 180° and 360°. As a result, sinewaves A and B are said to be "in phase."

Two sinewaves of the same frequency, but 180° out-of-phase, are shown in Figure 6-5B. The positive peak of sinewave A occurs at 90°, while the positive peak of sinewave B occurs at 270°. In this case, the two sinewaves are 270° - 90°, or "180° out-of-phase".

In Figure 6-5C, the positive peak of sinewave A occurs at 90°, and the positive peak of sinewave B occurs at 180°. The difference between the positive peaks is 180° - 90° = 90°. Thus, sinewaves A and B are "90° out-of-phase".

An oscilloscope can be used to measure the phase angle between two sinewave signals of the same frequency. To make a phase measurement, one signal is applied to the vertical amplifier, and the other signal is applied to the horizontal amplifier. The result is a Lissajous pattern.

Figure 6-6 shows the Lissajous patterns produced when signals of various phase relationships are applied to the horizontal and vertical amplifiers. If the two signals applied to the oscilloscope are in phase, a straight line slanted from the upper right to the lower left will be produced, as shown in Figure 6-6A. The Lissajous pattern produced for two signals 90° out-of-phase is a circle (when their amplitudes have the proper relationship), as shown in Figure 6-6B. Two signals 180° out-of-phase produce a line slanted from the upper left to the lower right, as shown in Figure 6-6C. Signals which have a phase difference other than 0°, 90°, and 180° produce ellipses of various shapes.

PROCEDURE

1. Be sure that the design console is turned off.
2. Set up the circuit of Figure 6-7 on the design console.
3. Turn on the design console.
4. Turn on your oscilloscope.

TEST NO. 1

1. Set the TIME/CM switch to the EXT × 10 position (maximum clockwise).

2. Set the VOLTS/CM switch to the 5.0 position, and adjust the VARIABLE control to its maximum counterclockwise position.

3. Set the AC/GND/DC switch to the AC position.

4. Connect the GND (shield) of the scope test lead to the ground point in the circuit.

5. Use the red DMM lead to connect from test point C in the circuit to the scope EXT INPUT jack.

6. Adjust the SWEEP VAR/HORIZ GAIN control to obtain a trace about 4 cm wide.

7. Adjust the INTENSITY, FOCUS, VERT POS and HORIZ POS controls to obtain a clear trace properly centered. The trace may consist of two narrowly separated lines due to stray 60 Hz ac pickup. In most cases, this condition is normal.

8. Observe the voltage at test point C (connect the center conductor of the scope lead to test point C) and adjust the VARIABLE control to obtain one of the patterns of Figure 6-8. (With the shield of the scope test lead grounded, you are actually observing the voltage between test point C and ground.)

Ideally, the pattern of Figure 6-8A should be obtained. However, the pattern of Figure 6-8B is what you probably will observe. As explained, the double trace is due to stray ac pickup and does not indicate any circuit defect.

TEST NO. 2

1. Observe the voltage at test point A by connecting the scope lead's center conductor to this point. You should obtain either of the patterns illustrated in Figure 6-9. Again, you will probably obtain a pattern similar to Figure 6-9B, rather than the ideal pattern of Figure 6-9A.

TEST NO. 3

1. Observe the voltage at test point B.

2. Adjust potentiometer R_1 on the design console (see Figure 6-7) to obtain a pattern without any tilt. Any one of the patterns shown in Figure 6-10 may be obtained. If the pattern of either Figure 6-10B or 6-10C is obtained, adjust the scope gain controls (both the Vertical and Horizontal VARIABLE controls) to cause it to look like Figure 6-10A.

The three patterns of Figure 6-10 represent a phase difference of 90° between the horizontal and vertical deflection voltages. Pattern 6-10A is obtained when the horizontal and vertical deflection voltages are equal in amplitude; pattern B is obtained when the horizontal voltage is less than the vertical voltage; pattern C is obtained when the vertical voltage is less than the horizontal voltage.

3. Potentiometer R_1 adjusts the amount of tilt of the trace because it varies the phase of the voltage at point B in relation to point C, while the gain controls on the scope determine the height and width of the pattern. Adjust all three controls to obtain the circle of Pattern 6-10A. It is normal for the circle to have slight imperfections. To obtain a perfect circle, the deflection voltages must be perfect sinewaves. Unfortunately, power transformers distort the sinewave a little, so that a perfect circle will not be obtained.

4. Adjust R_1 fully clockwise; the pattern will tilt to the left, as shown in Figure 6-9. The resistance in the circuit is very low, so that point B of Figure 6-7 is electrically about the same as point A. This causes the 180° phase shift pattern of Figure 6-9.

5. Adjust R_1 fully counterclockwise; the pattern will tilt to the right, as shown in Figure 6-8. Now, the full resistance of R_1 is in the circuit. The reactance of C_1 is small compared to the resistance of R_1, and point B is electrically almost the same as point C. The in-phase pattern of Figure 6-8 is the result.

6. Turn off the Design Console.

EXPERIMENT 4

TIME MEASUREMENT

PARTS NEEDED

1 - Design Console

1 - Oscilloscope with Test Leads

DISCUSSION:

In addition to measuring the amplitude of a signal, an oscilloscope can be used to measure the time duration of a pulse, or the duration of one complete cycle of an unknown signal. By obtaining the time duration of one cycle of a signal, the frequency of the unknown signal can be calculated.

To determine the time duration of a pulse or cycle of a signal, observe the width in centimeters of one cycle of the signal being measured. The markings of the TIME/CM switch indicate the time required for the scope's electron beam to sweep one centimeter of the graticule in the horizontal plane (the SWEEP VAR/HORIZ GAIN must be in the calibrate position). For example, with the switch in the 2 μS position, the beam will sweep one centimeter from left to right of the graticule in 2 microseconds. If the switch were in the 2 ms position, it would take two milliseconds for the trace to sweep one centimeter of the graticule.

After you obtain the necessary information (setting of TIME/CM Switch, number of centimeters, and number of cycles), you can calculate the time (t) duration using the following equation:

$$t = (\text{TIME/CM setting}) \times (\text{number of cm} \div \text{number of cycles}).$$

TEST NO. 1

1. Turn on the oscilloscope and allow it to warm up.

2. Connect the scope test lead to the INPUT.

3. Set the TRIGGERING switches in the following positions: AUTO, +, AC, INT.

4. Adjust the TRIG LEVEL control to obtain a trace.

5. Adjust the FOCUS and INTENSITY controls for the sharpest trace.

6. Set the VOLTS/CM switch to the 5.0 position.

7. Set the TIME/CM switch to the 2 mS position. Place the SWEEP VAR/HORIZ GAIN in the CAL position.

8. Turn the design console frequency adjustment control fully counterclockwise.

9. Connect the ground of the scope lead to the design console REG. DC (-) terminal.

10. Connect the center conductor of the scope test lead to the design console square wave terminal.

11. Set the oscilloscope AC/GND/DC switch to the AC position.

12. Center the trace.

13. Turn the design console on.

14. Adjust the TRIG LEVEL control for a stable trace.

15. Adjust the VERT control so that the negative peaks are located on the horizontal center line.

16. Adjust the HORIZ control so that the start of the first negative peak is located at the intersection of the horizontal center line and the fourth major vertical line left of center.

17. Count the number of cm between the start of the first negative peak and the start of the second negative peak. ____________ cm.

18. Calculate the time duration of the cycle using the equation:

t = (TIME/CM switch setting) × (number cm ÷ number of cycles).
____________ sec.

TEST NO. 2

1. Turn the design console frequency adjust control fully clockwise.

2. Set the oscilloscope TIME/CM switch to 200 μS.

3. Follow the procedure of Test No. 1 and determine the time duration of one cycle. ____________ sec.

4. Your calculated value for Step 18, Test No. 1, should be approximately 3.0 milliseconds, while in Step 3 of this test, the answer should be approximately 400 microseconds.

5. Turn off the design console.

EXPERIMENT 5

FREQUENCY MEASUREMENT

PARTS NEEDED

1 - Design Console
1 - DMM
1 - Oscilloscope with Test Lead
10 - Modular Connectors
2 - NPN Transistors
1 - 1 MΩ Potentiometer with Leads and Bracket
1 - 2.2 kΩ, 1/2W, 5% Resistor
1 - 10 kΩ, 1/2W, 20% Resistor
2 - 22 kΩ, 1/2W, 20% Resistors
1 - 47 kΩ, 1/2W, 20% Resistor
1 - 100 kΩ, 1/2W, 20% Resistor
1 - .01 μF Disc Capacitor
2 - Tri-Mounts

DISCUSSION

In the previous experiments, the oscilloscope was used to make time measurements. Since time and frequency are inversely related, an oscilloscope can be used to measure frequency. Frequency measurements can be made by comparing the unknown frequency to that of the oscilloscope's sweep generator frequency. This sweep generator frequency can be controlled by the settings of the TIME/CM switch.

When using the oscilloscope to measure frequency, we need to know the setting of the TIME/CM switch and the number of centimeters per cycle of the signal. To determine the frequency, we use the following equation:

$$\text{frequency} = \frac{1}{\text{time}} \text{ or,}$$

$$f = \frac{1}{t}$$

where: t = (the setting of the TIME/CM switch) × (the number of cm ÷ number of cycles).

For example, if the TIME/CM switch is in the 20 μS position, and we count one cycle of the signal in 10 cm, then t equals:

20×10^{-6} (the setting of the TIME/CM switch) × 10 cm (duration of one waveform cycle) ÷ 1 cycle or:

$$(20 \times 10^{-6}) \times \frac{10}{1} = 10^{-5} \times 20 = 2 \times 10^{-4}$$

Therefore: $f = \frac{1}{2 \times 10^{-4}} = \frac{10^4}{2}$, or 5 kHz,

$$f = 5 \text{ kHz.}$$

If, with the same TIME/CM switch setting, we observe 1 cycle in 2 cm of horizontal deflection, we would calculate the frequency:

$$f = \frac{1}{t}$$

$$t = (20 \times 10^{-6}) \times (2/1) = 40 \times 10^{-6}$$

$$= 40 \ \mu\text{seconds}$$

$$f = \frac{1}{40 \times 10^{-6}} = 25 \text{ kHz.}$$

TEST NO. 1

1. Turn on the scope and allow it to warm up.

2. Set the TRIGGERING switches in the following positions: AUTO, +, AC, INT.

3. Adjust the TRIG LEVEL control to obtain a trace.

4. Adjust the FOCUS and INTENSITY controls for the sharpest trace.

5. Set the VOLTS/CM switch to the 5.0 position and the VARIABLE in the CAL position.

6. Set the TIME/CM switch to the 2 mS position and the SWEEP VAR/HORIZ GAIN in the CAL position.

7. Connect the scope test lead to the INPUT.

8. Connect the center conductor of the scope test lead to the sinewave terminal of the design console.

9. Connect the scope ground to REG DC (-).

10. Turn on the design console and adjust the frequency adjustment control for a display of 5 complete cycles in 7 cm.

11. Adjust the VERT control so that the waveform is equally above and below the center line of the graticule.

12. Adjust the HORIZ POS control so that the first positive-going slope of the waveform crosses the intersection of the horizontal centering line and the leftmost line of the graticule.

13. Calculate the frequency of the signal displayed, using the equation:

$$f = \frac{1}{t}$$

where: $t = (\text{TIME/CM setting}) \times (\text{number cm} \div \text{number of cycles})$.

The frequency should have been calculated as follows:

$$f = \frac{1}{t}$$

where:

$$t = (2 \times 10^{-3}) \times (7 \div 5)$$

$$t = (2 \times 10^{-3}) \times (1.4)$$

$$t = 2.8 \times 10^{-3}$$

$$f = \frac{1}{2.8} \times 10^{-3} = 357 \text{ Hz or approximately } 360 \text{ Hz.}$$

14. To prove that the output of the sinewave generator is approximately 360 Hz, connect the 1V p-p 60 Hz jack to the EXT INPUT.

15. Set the TIME/CM switch to the EXT IN (×1) position.

16. You should obtain a 6 to 1 Lissajous pattern similar to that shown in Figure 6-11. The Lissajous pattern may drift slightly because the sinewave output frequency is not exactly 360 Hz. To stabilize the pattern, carefully adjust the frequency adjust control on the design console to obtain the 6 to 1 pattern of Figure 6-11.

TEST NO. 2

1. Construct the circuit in Figure 6-12 on the design console following Layout 6-1.

2. Turn on the design console and set the ADJUST VOLTAGE control to 5 volts.

3. Set the oscilloscope VOLTS/CM switch to the 2.0 position, with the VARIABLE control in the CAL position.

4. Set the TIME/CM switch to 2 mS position, with the SWEEP VAR/HORIZ GAIN control in the CAL position.

5. Adjust the scope for sharpest possible centered trace.

6. Connect the ground of the scope test lead to the ground of the circuit.

7. Connect the center conductor of the scope test lead to the output point of the circuit (refer to Layout 6-1).

8. Readjust the TRIG LEVEL control to obtain a stable display on the scope. Align a positive or negative going edge of the waveform with one of the vertical lines on the graticule.

9. Using the procedure in Test 1 of this experiment, calculate the frequency. ____________ Hz.

10. Turn off your design console, and replace the 10 μF electrolytic capacitor with a .1 μF disc capacitor.

11. Calculate the frequency. ____________ Hz.

The calculated frequencies in Steps 9 and 11 should be approximately 66 Hz and 12.5 kHz, respectively. Your answers should be close to these values.

EXPERIMENT 6

SETTING THE TIME BASE

PARTS NEEDED

1 - Oscilloscope	1 - Design Console

DISCUSSION:

In this project you will set the time base (sweep rate) of the oscilloscope to a sweep rate different than that which can be set by the TIME/CM switch. This will be done by applying a known frequency signal to the input and adjusting the SWEEP/VAR control. The reason for this type of adjustment is that it sometimes may be more convenient to reset the time base to rapidly and accurately determine the unknown frequency of a signal under observation.

TEST NO. 1

1. Connect a wire from the 1V P-P 60 Hz jack to the EXT INPUT.

2. Connect the scope test lead to the sinewave output of the design console and the ground to REG DC (-).

3. Set the VOLTS/CM switch to the 5 position.

4. Set the TIME/CM switch to the EXT IN (×1).

5. Turn on the design console and the scope.

6. Adjust the VERT POS and HORIZ POS to center the display.

7. Adjust the frequency adjustment control on the design console for a 6 to 1 Lissajous pattern, as shown in Figure 6-11.

8. Disconnect the 1V p-p 60 Hz signal from the EXT INPUT.

9. Connect the center conductor of the scope test lead to the 1V p-p 60 Hz input. It will be necessary to readjust the VOLTS/CM switch.

10. Set the TIME/CM switch to the 2 µS position.

11. Adjust the TRIG LEVEL for a stable display.

12. Position the trace in the center of the CRT screen.

13. Rotate the SWEEP VAR/HORIZ GAIN control counterclockwise until a half cycle of the observed waveform occupies 8.3 cm. Since one-half cycle of 60 Hz occurs in 8.4 milliseconds, the sweep rate is now adjusted for 1 millisec/cm.

14. Connect the center conductor of the scope test lead to the sinewave output and the ground lead to REG DC (-) terminal. DO NOT disturb the setting of the frequency adjust control. It will be necessary to readjust the VOLTS/CM switch.

15. Calculate the frequency of the signal. ____________ Hz. Remember you have readjusted the sweep rate to 1 ms/cm.

16. Readjust the frequency adjustment control for 10 cycles in 10 cm.

17. Calculate the new frequency ____________ Hz.

The calculated frequencies in Step 15 and 17 should be approximately 360 Hz and 1 kHz, respectively. Your answers may not agree with these values, but they should be close.

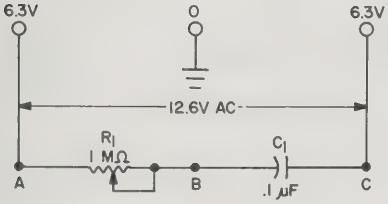


FIGURE 6-1

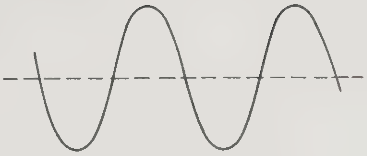


FIGURE 6-2

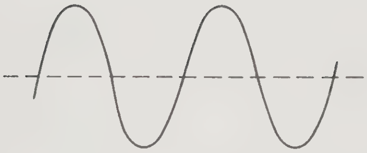


FIGURE 6-3

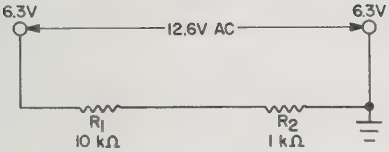


FIGURE 6-4

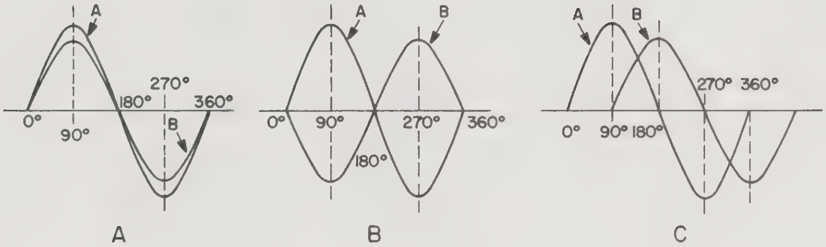


FIGURE 6-5

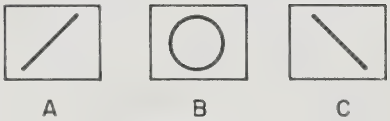


FIGURE 6-6

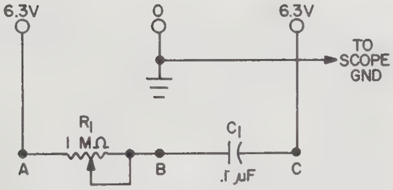


FIGURE 6-7

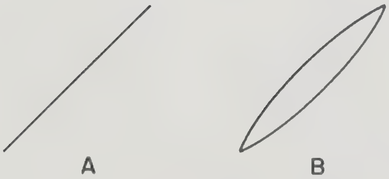


FIGURE 6-8

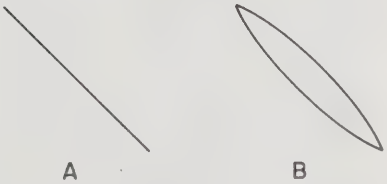


FIGURE 6-9

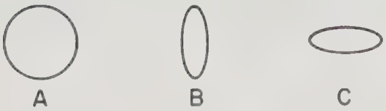


FIGURE 6-10

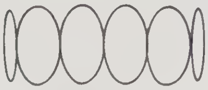


FIGURE 6-11

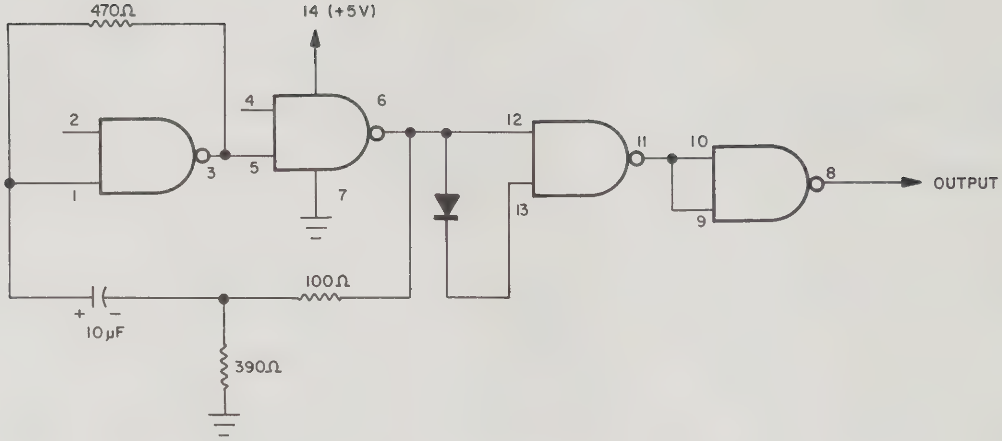
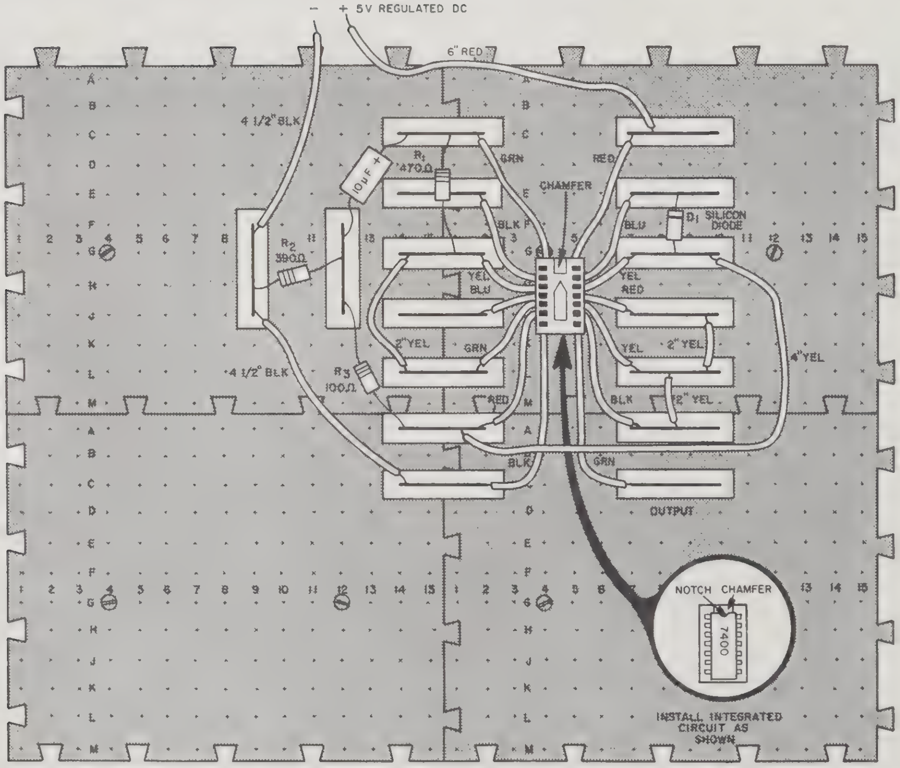


FIGURE 6-12



LAYOUT 6-1

PROJECT 7

OSCILLOSCOPE OPERATION EXERCISES

PARTS NEEDED

1 - Design Console

1 - Oscilloscope Test Lead

1 - 1 MΩ Potentiometer with Leads and Bracket

1 - 1 kΩ, 1/2W, 20% Resistor

1 - 1.8 kΩ, 1/2W, 10% Resistor

1 - 3.9 kΩ, 1/2W, 20% Resistor

1 - 10 kΩ, 1/2W, 20% Resistor

1 - 47 kΩ, 1/2W, 20% Resistor

1 - Silicon Diode

- No. 22 Solid Hookup Wire

2 - NPN Transistors

3 - Transistor Sockets with Leads

14 - Modulator Connectors

2 - 10 µF, 50 V dc Electrolytic Capacitors

2 - Tri-Mounts

DISCUSSION

In this project you construct a test circuit and perform several exercises using your oscilloscope. If you have trouble, refer to the associated experiment in Project 6. The appropriate experiment in Project 6 will be listed with each step in this project, if needed.

PROCEDURE

1. Construct the circuit of Figure 7-1, following Layout 7-1.
2. Adjust the REG DC output voltage for +20 volts. (Experiment 2 Test 3)

3. Set the frequency adjustment control on the design console to its center of rotation.

4. Adjust R1 in the test circuit for a 2V p-p signal on its wiper. (Experiment 2 Test 1)

5. Measure and record the peak-to-peak voltage at the base of Q1. ________________ V p-p. (Experiment 2 Test 1)

6. Measure and record the peak-to-peak voltage at the collector of Q1. ____________ V p-p. (Experiment 2 Test 1)

7. Calculate the gain of Q1.

8. Determine if there is a phase difference between the signal at the collector of A1 and the input signal. __________ (Experiment 1, Test 1 or Experiment 3, Test 1)

9. What is the phase difference, if any? __________ (Experiment 3 Discussion)

10. What is the frequency of the signal? __________ Hz

11. Disconnect the input sinewave signal by removing the wiper lead of R1 from modular connector A. (Refer to Layout 7-1).

12. Measure the dc volts at the collector of Q1 using your scope. ____________ volts (Experiment 2 Test 3)

13. Measure the dc volts at the emitters of Q2 and Q3. ____________ volts. (Experiment 2 Test 3)

14. Reconnect the wiper arm lead of R1 to modular connector A.

15. Measure and note the peak-to-peak voltage at the base of Q2. __________ volts. (Experiment 2 Test 1)

16. Determine if there is a phase difference between the base signal of Q3 and the emitter signal of Q3. ____________ (Experiment 3 Test 1)

17. Determine if there is a phase difference between the input signal to the circuit and the output signal of the circuit. ____________ (Experiment 3 Test 1)

18. Measure and note the peak-to-peak voltage at the emitter of Q1 ________ V p-p. (Experiment 2 Test 1)

19. Rotate the design console frequency adjustment control fully clockwise.

20. Calculate the output frequency of the test circuit.

21. Using the design console, set up a 10 to 1 Lissajous pattern. (Experiment 5 Test 1)

22. Without disturbing the frequency adjustment control on the design console, adjust the scope trace for 1 cycle in 10 cm, using the design console sinewave output. (Experiment 6 Test 1)

23. Calculate the sweep rate. __________. (Experiment 5 Test 1)

24. Turn the frequency adjustment control on the design console fully clockwise.

25. Calculate the output frequency of the test circuit. ____________ Hz. (Experiment 5 Test 1)

The answers to Project 7 are found at the end of this manual. Your answers may not agree exactly with the answers given, but they should be close.

When it is necessary for you to make waveform observations in commercial electronics equipment, or in some of our later laboratory experiments, specific settings for the scope controls are not given. In many instances, the instructions are as follows: "Set the controls of your oscilloscope to observe a 15,750 Hz signal with a peak-to-peak amplitude of 35 volts." It is assumed that you have sufficient knowledge to set your oscilloscope controls to the proper positions to observe the waveform.

In other instances, specific settings for a different scope are given and you must convert this information to the proper settings for your scope. Charts 1, 2 and 3 illustrate the controls on your scope that are the equivalent of controls on other scopes.

ANSWERS TO PROJECT 7

5. 2V p-p

6. Approximately 8V p-p

7. Approximately 4

9. 180°

10. Approximately 525 Hz (Your answer will vary depending upon the setting on the frequency adjustment control.)

12. Approximately 10.5 volts

13. Approximately 10 volts

15. Approximately 8V p-p

16. 0°

17. 180°

18. Approximately 1.9V p-p

20. 2.7 kHz

23. 167 μS/CM

24. 2.7 kHz

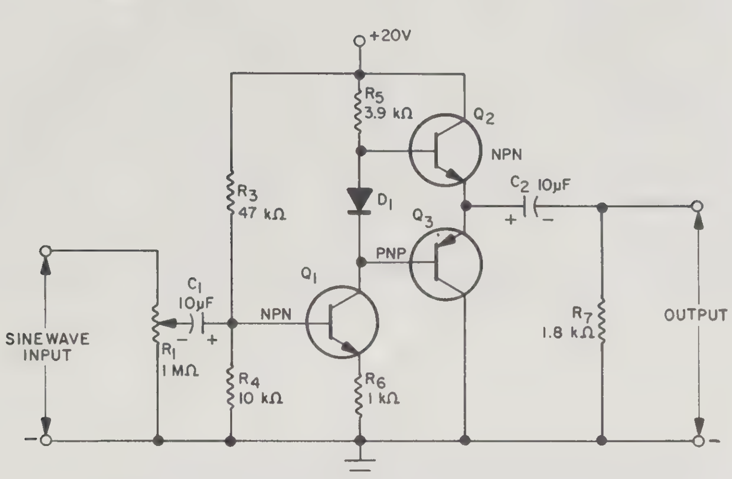
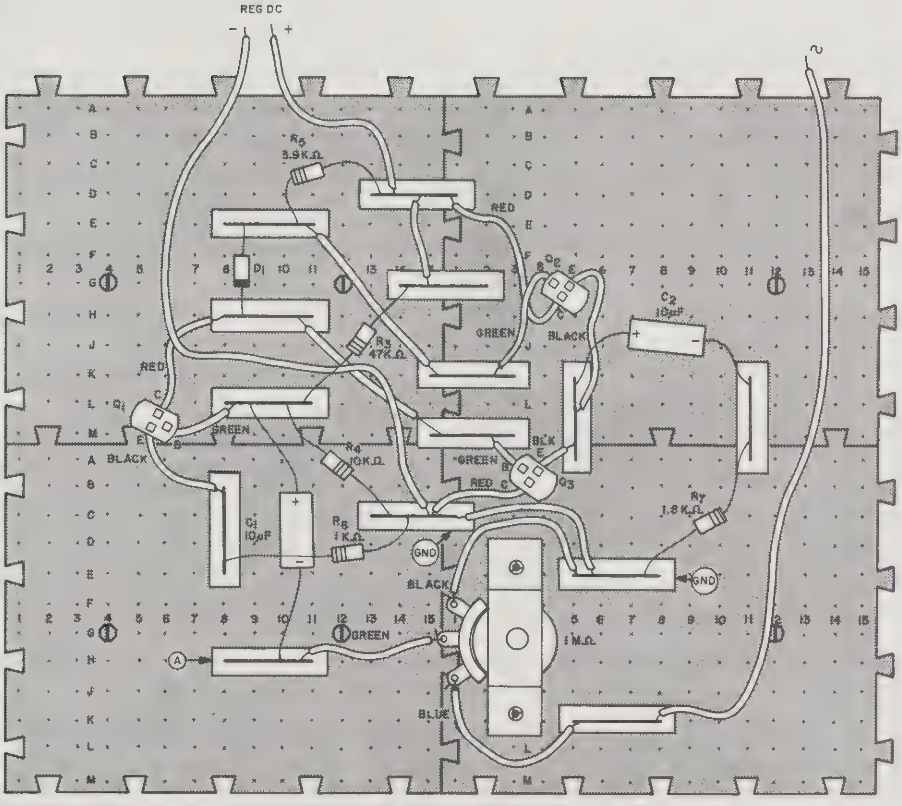


FIGURE 7-1



LAYOUT 7-1

VERTICAL CONTROLS

IOD-4540	Other Scopes
VOLTS/CM	Peak-to-Peak Volts
VARIABLE	Vertical Gain
VERT POS	Vert. Centering

Chart 7-1

HORIZONTAL CONTROLS

IOD-4540	Other Scopes
TIME/CM	μSec/CM, mSec/CM or Sweep Time/CM
SWEEP VARIABLE	Variable
HORIZ GAIN	Width
HORIZ POS	Hor. Centering

Chart 7-2

SWEEP TRIGGER CONTROLS

IOD-4540	Other Scopes
TRIG LEVEL	Level and/or Stability
INT EXT LINE	Int. Ext
SLOPE	Slope or Polarity
AUTO NORMAL	Auto Norm or Recurrent Triggered
AC DC TV	Same or not used.

Chart 7-3

QUESTIONS

IMPORTANT — These instructions **MUST** be accurately followed to avoid loss, or errors in grading.

Indicate your answer on this sheet by filling in the box for the most correct answer to each question.

When all questions have been answered, place the answer card in the proper position to line up the boxes on the card with the boxes on the sheet.

Next, copy the complete lesson code into the space provided on the card, and fill in the answer boxes to correspond with those previously filled in on this sheet.

Before mailing, be certain your correct student number, name and address appear on the card.

LESSON CODE
9575-3A

1. Assume that the VOLTS/CM switch is set to 0.5, and the VARIABLE control is fully clockwise. A trace 5 cm high corresponds to a voltage of
(A) .25V rms. (B) 2.5V p-p. (C) .25V p-p. (D) 2.5V rms.
A ☐ B ☒ C ☐ D ☐

2. If a phase measurement on your oscilloscope shows a circular pattern, the phase shift is
(A) 180° (B) 0° (C) 90° (D) 45°
A ☐ B ☐ C ☒ D ☐

3. When +5V dc is measured with the VOLTS/CM switch in the 2 position, and the AC/GND/DC switch in the DC position, the trace will move
(A) 4.5 cm in the negative direction. (B) 2.5 cm in the positive direction. (C) 4 cm in the positive direction. (D) 2 cm in the negative direction.
A ☐ B ☒ C ☐ D ☐

4. If a phase measurement on your oscilloscope shows a straight line slanted from the upper right to the lower left, the phase shift is
(A) 0° (B) 90° (C) 45° (D) 180°
A ☒ B ☐ C ☐ D ☐

5. Assume that the oscilloscope is calibrated and the TIME/CM switch is set to the 20 μS position. If a complete cycle of a signal occupies 5 cm, the frequency is
(A) 1 kHz (B) 10 kHz (C) 100 kHz (D) 1 MHz
A ☐ B ☒ C ☐ D ☐

100×10^{-6} 10^{7}

6. If the VOLTS/CM switch is set to the 0.2 position and a sinewave signal being observed occupies 8 cm, what is the peak-to-peak value?
(A) 16V p-p. (B) .8V p-p. (C) .16V p-p. (D) 1.6V p-p.
A ☐ B ☐ C ☐ D ☒

7. If 3 cycles of a signal occupy 4 cm on the oscilloscope, and the TIME/CM switch is in the 1 mS position, the signal frequency is
(A) 66 Hz. (B) 66 kHz. (C) 666 Hz. (D) 6.6 kHz.
A ☐ B ☐ C ☒ D ☐

1.33×10^{3}

$\frac{4x}{3} 10^{-3} =$ ~~$\frac{3}{4} \times 10^{3}$~~

8. If the time duration of a pulse is 100 μSec and there are two pulses appearing in one cm, the TIME/CM switch setting is
(A) 200 μS. (B) 2 μS. (C) 200 ms. (D) 20 ms.
A ☒ B ☐ C ☐ D ☐

$\frac{10^{3}}{1.33}$

$1.33 \overline{)1000}$ 7
931
670

9. If a 1 kHz signal is observed and the sweep rate is adjusted for one cycle per cm, the TIME/CM switch setting is
(A) 2 mS. (B) 200 μS. (C) 20 μS. (D) 20 mS.
A ☒ B ☐ C ☐ D ☐

10. If 2 cycles of a signal occupy 5 cm on an oscilloscope and the TIME/CM switch is in the 100 mS position, the signal frequency is
(A) 40 Hz. (B) 10 Hz. (C) 4 Hz. (D) 20 Hz.
A ☐ B ☐ C ☒ D ☐